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CENTRAL FLORIDA PHOSPHATE INDUSTRY AREAWIDE IMPACT ASSESSMENT PROGRAM

Volume VI: Land

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Before there could be an evaluation of the effects that activities of the central Florida phosphate industry have on the natural environment existing in Charlotte, DeSoto, Hardee, Hillsborough, Manatee, Polk, and Sarasota counties, there had to be a basic description of that environment. This is accomplished for the physical, geochemical, and radiation environments and for the terrestrial ecology of the 7-county area in Volume VI of Texas Instruments 7-volume environmental impact assessment. The physical environment pertains to the existing structure, natural surface features, and surface cover (soils). The geochemical environment is considered from the standpoint of the geochemistry of the phosphate ore body and its surrounding zones. Discussion of the radiation environment encompasses activities that redistribute radioactive elements. The terrestrial biota section reviews local vegetation types, important plant species within the types, and the abundance ratings of the terrestrial vertebrates that are present. Important wetlands biota is identified and the relative productivity of the communities and their overall biological importance addressed.

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FOREWORD

This is one in a series of reports presenting information developed by, or supplied to, Texas Instruments Incorporated (TI) while conducting an areawide environmental impact assessment of the central Florida phosphate industry for the Environmental Protection Agency (EPA). Because of the diversity and number of groups and individuals interested in this program, the EPA and TI encouraged active public involvement by making working papers available for review and comment as they were developed through environmental analysis, impact assessment, and alternative selection. These working papers then were prepared as a series of reports incorporating the original material modified through the incorporation of comments and additional information developed by TI. Other reports in the series include:

Volume	Title
I	Program and Industry Description
II	Environmental Permits and Approvals Relating to Phosphate Mining and Fertilizer Manufacturing in Florida
III	Socioeconomics
IV	Atmosphere
V	Water
VII	Impacts of Alternative Public Policies on Social, Economic, and Natural Environmental Systems

These reports are made available through the National Technical Information Service to serve as background information to the environmental statements (draft and final) and environmental planning needs of federal, state and local agencies as well as other interested parties. The information will be of value to those involved with development and regulation of the phosphate industries, others who plan developments in central Florida, and environmental planners in general who must deal with environmental issues on a regional basis. It is hoped their use will lead to good decisions. It has often been said that decisions are only as good as the information on which they are based. Extending that philosophy, decisions are only as good as the decision makers' understanding of the adequacy of the information in resolving the issues being examined.

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SECTION 1
INTRODUCTION

To evaluate properly the effects that activities of the central Florida phosphate industry have on the existing natural environment of the 7-county study area (Charlotte, DeSoto, Hardee, Hillsborough, Manatee, Polk, and Sarasota), it is essential that an understanding of that environment be developed. Toward such an understanding, this volume presents sections on the physical (Section 2), geochemical (Section 3), and radiation (Section 4) environments and on the terrestrial ecology of the study area (Section 5). These, together with Volume IV on the atmosphere and Volume V on hydrology, constitute the basic description of the natural environment of the study area.

The physical environment pertains to the land as it exists, i.e., its structure, natural surface features, and surface cover (soils). The geochemical environment is considered from the standpoint of the phosphate ore body, viz., the geochemistry of the ore body and its surrounding zones. Discussion of the radiation environment goes beyond that of merely describing naturally occurring radioactive elements and their natural distribution; rather, it encompasses activities of the phosphate industry that redistribute these elements. The biota described includes both terrestrial (this volume) and aquatic (Volume V).

SECTION 2

PHYSICAL ENVIRONMENT

A. GEOLOGY

1. General

The great projection of the North American continent dividing the Atlantic Ocean and the Gulf of Mexico is known as the Floridian plateau (Cooke 1945). This plateau trends N 15° W and supports peninsular Florida, a gently emergent peninsula with broad continental shelves to the west and east (Altschuler et al 1964). This peninsula, little more than 99 meters (325 feet) above sea level, lies predominantly east of the axis of the Floridian plateau. The peninsula and the plateau terminate at the Florida Keys and the Straits of Florida respectively.

Peninsular Florida can be divided into a northern clastic platform consisting primarily of pieces of older original rocks and into a southern basin made up mainly of carbonate (limestone and dolomitic limestone) deposition known as the south Florida embayment. (See Figure 2.1 and Table 2.1).

Limestone, clay, and sand are common throughout the subsurface of Florida, but the essential contrast between the northern and southern portions of the state is that of a thin clastic northern platform contrasted to a thick southern carbonate basin (Altschuler et al 1964). A number of large structural domes have been superimposed on the northern platform, with the Ocala uplift immediately north of the study area exerting a strong influence on subsurface and surface conditions. As defined by Altschuler et al (1964), the Ocala uplift is a broad, elongate dome composed of Tertiary and Quaternary rocks of the Floridian plateau and underlain by a core of Paleozoic and older rocks (Precambrian). This dome trends southeasterly and plunges to the southeast. At its crest, the top of the Ocala limestone (the formation used to define the uplift) is 46 meters (150 feet) above sea level; in the vicinity of Clearwater, it drops to 137 meters (450 feet) below sea level; and in Monroe County at the south end of the state, it is 366 meters (1200 feet) below sea level, an apparent average dip of about 0.95 meters per kilometer (5 feet per mile)

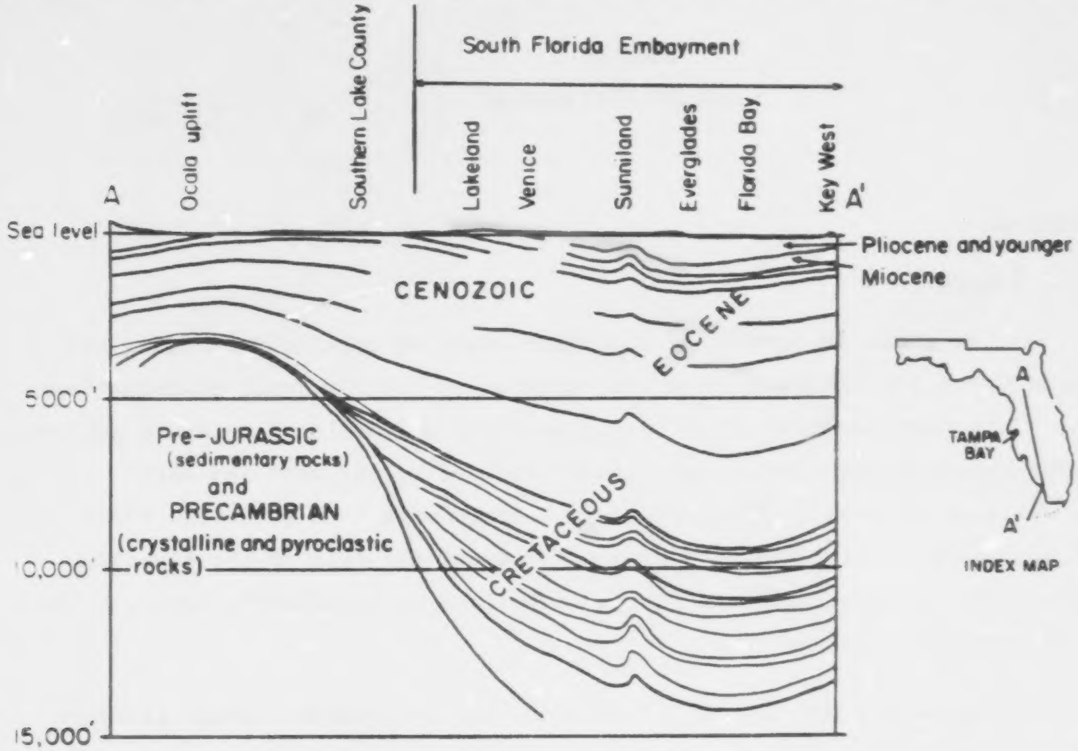

South Florida Embayment
A
Ocala uplift
Southern Lake County
Lakeland
Venice
Sunniland
Everglades
Florida Bay
Key West
A'
Sea level
Pliocene and younger
Miocene
CENOZOIC
EOCENE
5000'
Pre-JURASSIC
(sedimentary rocks)
and
PRECAMBRIAN
(crystalline and pyroclastic
rocks)
CRETACEOUS
10,000'
15,000'
A
TAMPA BAY
A'
INDEX MAP

Figure 2.1. Cross Section through Central Peninsular Florida (Pressler 1947, cited by Altschuler et al 1964)

over the entire region. Near the crest of the arch, the dip of the Ocala limestone exceeds 1.5-1.9 meters per kilometer (8-10 feet per mile). The dip (slope) of the rocks underlying the south Florida embayment, however, is thought to exceed 19 meters per kilometer (~100 feet per mile) (Altschuler et al 1964).

Altschuler et al (1964) further state that formations of Oligocene and Miocene age (Table 2.1) flank the Ocala uplift, dip away from it in all directions, and thicken to the south and east. Almost all Pliocene and younger formations, in contrast with Hawthorn (Miocene) and older strata, are thin, flat blankets of transgressive clastics in the lowland areas of central and northern peninsular Florida.

Table 2.1. Geologic Time Scale*

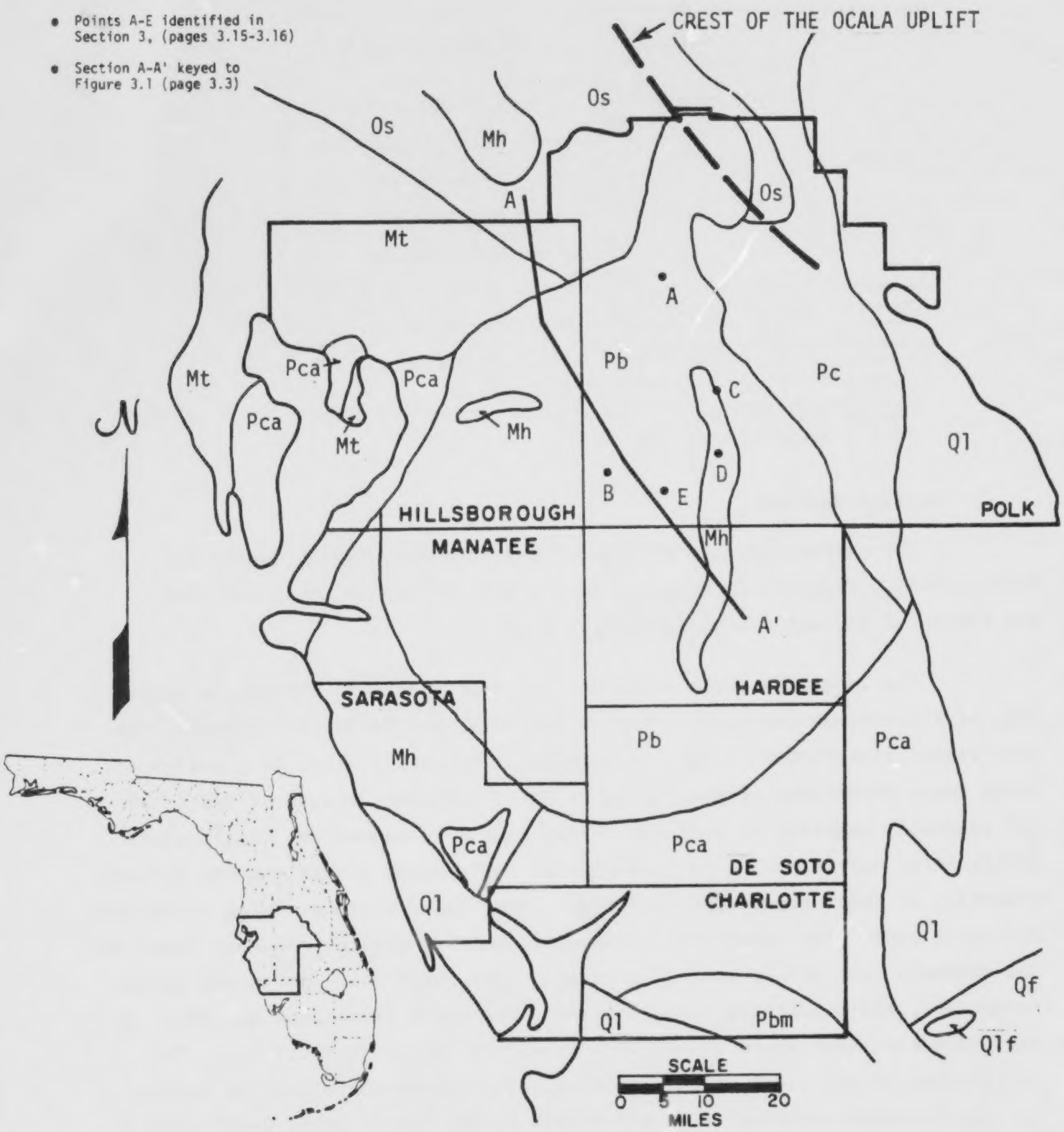
Era	Period	Epoch	Approximate Dates
Cenozoic	Quaternary	Recent	5,000 years B.P.**
		Pleistocene	2,000,000 years B.P.
	Tertiary	Pliocene	12,000,000 years B.P.
		Miocene	25,000,000 years B.P.
		Oligocene	38,000,000 years B.P.
		Eocene	55,000,000 years B.P.
		Paleocene	65,000,000 years B.P.
Mesozoic (includes Cretaceous period)			225,000,000 years B.P.
Paleozoic (includes Jurassic period)			600,000,000 years B.P.
Archeozoic (includes Precambrian period)			

*Wright 1974.
**B.P. = before present.

2. Surface Geology

The surface geology of Florida has been extensively mapped by Cooke (1945). Figure 2.2 sketches the surface geology of the study area, and Table 2.2 defines the surface formations.

The immediate surface (Recent) at most places in Florida is underlain by Pleistocene deposits, of which two principal kinds are defined. The most widely distributed, which is included in the study area, is a series of seven sandy formations corresponding to seven different stages of sea level and generally regarded as terraces. They appear to record the oscillations of sea level corresponding to interglacial and glacial stages and are defined primarily by their topographic relations, the higher terraces being older than the lower ones. The other type of deposit, which underlies the East Coast and the southern part of the state, is divided into three contemporaneous marine formations, all containing marine shells. The seven shorelines and their approximate altitudes above current sea level are listed in Table 2.3. The oscillation of sea level which gave rise to the seven shorelines is related to the alternate withdrawl from and return to the sea of great quantities of water which, while withdrawn or frozen, composed the great continental ice caps of the Pleistocene epoch. Glaciologists have defined four main ice ages separated by interglacial periods of relatively high sea level (Table 2.4).


CREST OF THE OCALA UPLIFT
Os
Os
Os
Mh
Mh
Mh
Mh
Mh
Mt
Mt
Mt
Pca
Pca
Pca
Pca
Pca
Pca
Pb
Pb
Pc
Ql
Ql
Ql
Ql
Qf
Qlf
Pbm
A
A
A'
B
C
D
E
HILLSBOROUGH
POLK
MANATEE
HARDEE
SARASOTA
DE SOTO
CHARLOTTE
N
SCALE
0
5
10
20
MILES

- Points A-E identified in Section 3, (pages 3.15-3.16)
- Section A-A' keyed to Figure 3.1 (page 3.3)

Figure 2.2. Surface Formations of Study Area (Cooke 1945) (See Table 2.2 for formation descriptions)

Table 2.2. Surface Formations of Study Area*

Series	Formation	Description
Pleistocene	Lake Flirt marl (Qlf)**	Freshwater marl and limestone of late Wisconsin and Recent ages; widely distributed as thin sheets throughout Everglades
	Late Pleistocene deposits (Ql)	Marine and estuarine terrace deposits less than 30 meters (100 feet) above sea level; includes Anastasia, Wicomico, Penholoway, Talbot, and Pamlico formations (see Table 1.3).
	Fort Thompson formation (Qf)	Three thin beds of marine shell marl separated disconformably by freshwater limestone; includes Coffee Mill hammock marl member at top
Pliocene	Bone Valley formation (Pb)	Marine and estuarine phosphatic sand, clay, gravel
	Citronelle formation (Pc)	Chiefly sand and white or iron-stained clay; some deposits so mapped are early Pleistocene
	Caloosahatchee marl (Pca)	Marine sand and shell marl
Miocene	Hawthorn formation (Mh)	Sandy phosphatic limestone weathering into vesicular sandstone or sand; in Gadsden County, includes large deposits of fuller's earth
	Tampa limestone (Mt)	Marine, very fine sandy limestone of early Miocene age; commonly chalky
Oligocene	Suwannee limestone (Os)	Hard white or cream-colored limestone commonly containing pockets of green residual clay

*Cooke 1945

**See Figure 2.2

Table 2.3. Seven Interglacial Shorelines of Westcentral Florida*

Shoreline	Altitude Above Current Sea Level meters (feet)
Brandywine	82.3 (270)
Caharie	65.5 (215)
Sunderland	51.8 (170)
Wicomico	30.5 (100)
Penholoway	21.3 (70)
Talbot	12.8 (42)
Pamlico	7.6 (25)

*Cooke 1945

The names of the four glacial periods - Nebraskan, Kansan, Illinoian, and Wisconsin - indicate generally the southernmost extent of glaciation. Each glacial stage was separated by comparatively ice-free periods - the Aftonian, Yarmouth, and Sangamon - which were probably of much greater duration. While the land was high above sea level during glaciations, erosion predominated, forming the terraces.

The surface to near-surface deposits of the study area assigned to the Pleistocene epoch vary greatly in lithologic character and thickness but are predominantly sandy. Recent surface deposits include fine sands blown into dunes along beaches; silt and sand deposits in tidal flats and in bars and floodplains along rivers in the area; muck and peat in ponds, shallow lakes, and mangrove swamps; and a kind of travertine or caliche formed locally near the surface (Cooke 1945).

3. Subsurface Geology

The oldest rocks exposed at the surface in the study area are those of the Suwannee limestone formation of Oligocene age (see Figure 2.2 and Table

Table 2.4. Pleistocene Epoch Formations of Florida*

<table>
<tr><th>Era</th><th>System</th><th>Series</th><th>Stage</th><th colspan="5">Formation</th></tr>
<tr><td rowspan="7">Cenozoic</td><td rowspan="7">Quaternary</td><td rowspan="7">Pleistocene</td><td>Wisconsin</td><td colspan="5">Erosion interval; Lake Flirt marl (freshwater, partly recent)
Pamlico sand (littoral; shoreline at 7.6 meters (25 feet)
Erosion Interval</td></tr>
<tr><td>Sangamon</td><td>Talbot formation (littoral; shoreline at 12.8 meters (42 feet)
Penholoway formation (littoral; shoreline at 21.3 meters (70 feet)
Wicomico formation (littoral; shoreline at 30.5 meters (100 feet)</td><td>Anastasia formation (marine)</td><td>Miami oolite (marine)</td><td>Key Largo limestone (marine)</td><td rowspan="5">Fort Thompson formation (marine and freshwater)</td></tr>
<tr><td>Illinoian</td><td colspan="4">Erosion interval; freshwater limestone in Fort Thompson formation</td></tr>
<tr><td>Yarmouth</td><td colspan="4">Sunderland formation (littoral; shoreline at 51.8 meters (170 feet)
Coharie formation (littoral; shoreline at 65.5 meters (215 feet)</td></tr>
<tr><td>Kansan</td><td colspan="4">Erosion interval; freshwater limestone in Fort Thompson formation</td></tr>
<tr><td>Aftonian</td><td colspan="4">Brandywine formation (littoral; shoreline at 82.3 meters (270 feet)</td></tr>
<tr><td>Nebraskan</td><td colspan="5">Erosion interval</td></tr>
</table>

*Cooke 1945

2.2) in extreme northern Polk and Hillsborough counties. The next oldest formation in the area is the very pure Ocala limestone of Eocene age (mentioned earlier as the defining formation for the Ocala uplift), which lies unconformably below the Suwannee. Rocks of the Paleocene epoch, the earliest epoch of the Tertiary period (Table 2.1), appear to be absent. Underlying the rocks of the Tertiary period are those of the Cretaceous period of the Mesozoic era, and beneath those are rocks of the Paleozoic era. The core of the Floridian plateau is probably Precambrian and is doubtlessly composed of ancient metamorphic rocks like those of the Piedmont region of Georgia (Cooke 1945).

The lithology and stratigraphy of the near-surface formations in the study area of interest to the phosphate mining industry are discussed at length in Section 3 of this document, and subsurface geology relative to the ground waters of the Floridan aquifer is discussed in Volume V.

B. GEOMORPHOLOGY

The Florida peninsula is a region of little crustal disturbance, and structures that exist are relatively low and broad and often difficult to define. The surface is remarkably flat because of its relative youth. Conditions in the past have led to some confusion in delineating the area's physiographic features (Altschuler et al 1964).

Cooke (1945) described Florida as consisting of five natural topographic divisions - the Tallahassee Hills, the Marianna Lowlands, the Western Highlands, the Central Highlands, and the Coastal Lowlands (Figure 2.3). Only the latter two are in the study area.

The land surface of the study area rises monotonously inland from the Gulf of Mexico across the Coastal Lowlands marine plain to essentially north-south elongated ridges and bars of low relief which characterize the Central Highlands. These ridges (Figure 2.4), which are named after nearby cities (viz., Lake Wales, Winter Haven, and Lakeland), are considered by Vernon (1970) to be barrier islands, beach ridges, or spits formed along ancient shorelines; together with the poorly drained and virtually undissected plains along the coast and the slightly rolling alluvial plains and shallow valleys of the

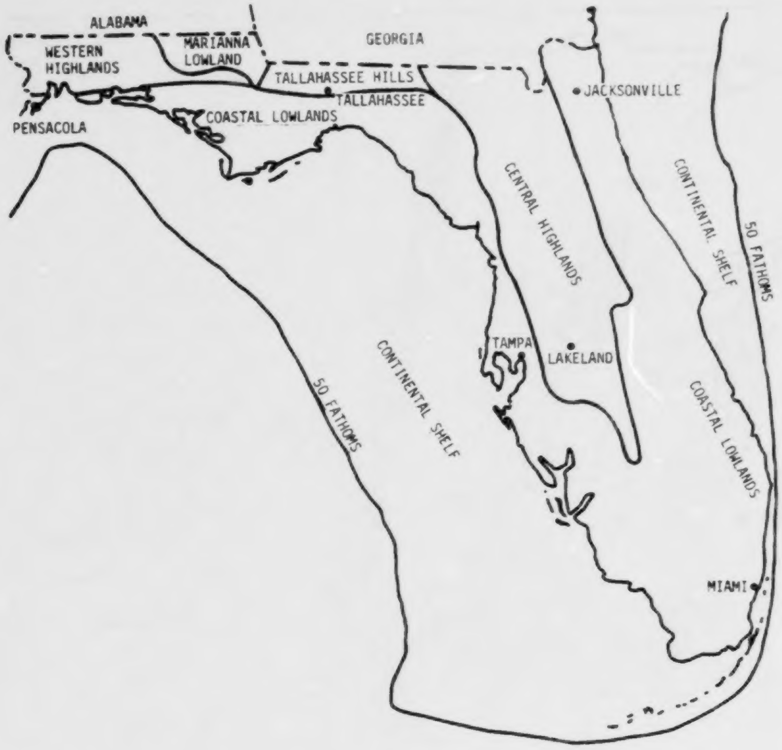

ALABAMA
WESTERN HIGHLANDS
MARIANNA LOWLAND
GEORGIA
TALLAHASSEE HILLS
TALLAHASSEE
JACKSONVILLE
PENSACOLA
COASTAL LOWLANDS
CENTRAL HIGHLANDS
CONTINENTAL SHELF
50 FATHOMS
TAMPA
LAKELAND
CONTINENTAL SHELF
50 FATHOMS
COASTAL LOWLANDS
MIAMI

Figure 2.3. Topographic Divisions of Florida (Cooke 1945)

Peace, Alafia, and Hillsborough rivers, they constitute the three principal types of terrain found in the study area (Figure 2.5).

The Lake Wales Ridge is a long, narrow highland extending southeasterly from the vicinity of the common corner of Polk, Osceola, Orange, and Lake counties at the northwest to a point a few miles north of Venus in southern Highlands County at the southeast; in most places, it rises abruptly from the lower, flatter surrounding lands. The ridge's surface is irregular, offering considerable local relief that appears to be the result of solution by ground water, stream erosion, and the building of sand dunes by wind deposition (White 1958). The Winter Haven and Lakeland ridges are west of the Lake Wales Ridge and are not as long or as high; they both terminate rather abruptly to the north where erosion has truncated the insoluble Miocene beds that support them. The Lake Wales Ridge and its supporting area of outcrop of Miocene beds, however, extend considerably farther to the north, dying out more gradually than the others.

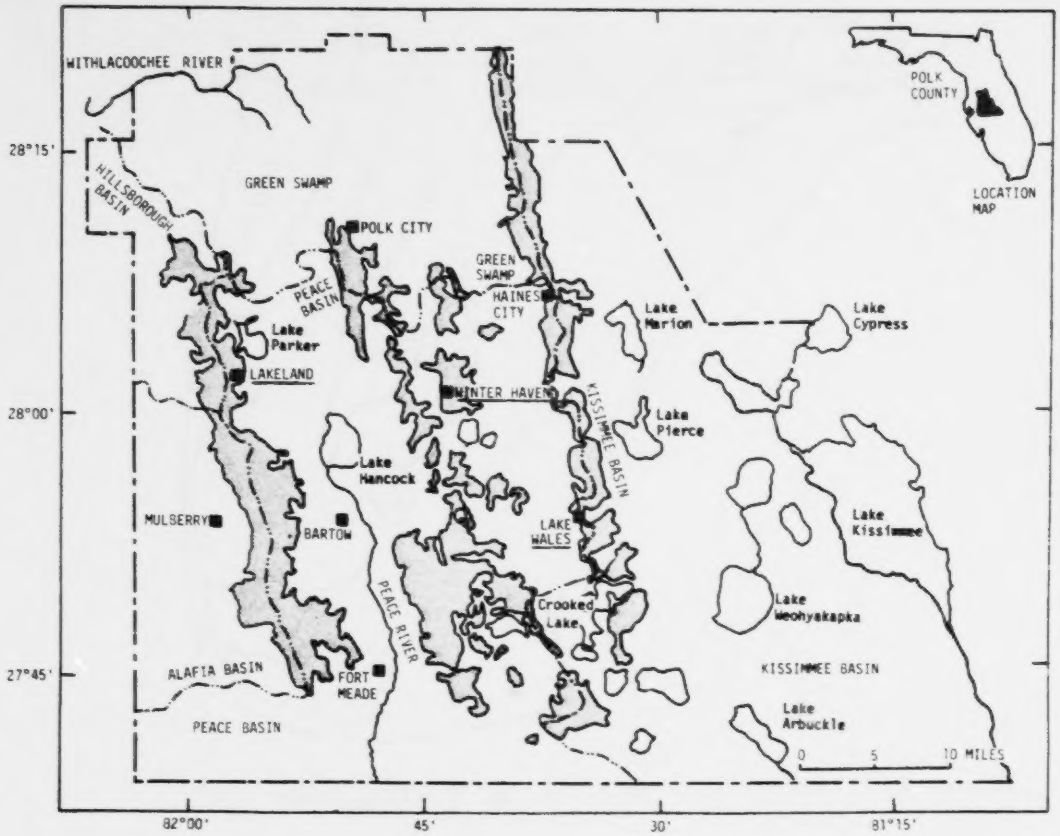

WITHLACOOCHEE RIVER
28°15'
HILLSBOROUGH BASIN
GREEN SWAMP
POLK CITY
GREEN SWAMP
HAINES CITY
PEACE BASIN
Lake Parker
LAKELAND
Lake Marion
Lake Cypress
WINTER HAVEN
KISSIMMEE BASIN
28°00'
Lake Pierce
Lake Hancock
MULBERRY
BARTOW
LAKE WALES
Lake Kissimmee
PEACE RIVER
Crooked Lake
Lake Weohyakapka
27°45'
ALAFIA BASIN
FORT MEADE
KISSIMMEE BASIN
Lake Arbuckle
PEACE BASIN
0 5 10 MILES
82°00'
45'
30'
81°15'
POLK COUNTY
LOCATION MAP

Figure 2.4. Locations of Lakeland, Winter Haven, and Lake Wales Ridges in Polk County (Robertson 1972)

Much of the eastern half of Polk County is occupied by the Polk Upland, a roughly square area surrounded by lower ground on three sides — on the south by the DeSoto Plain, on the west by the Gulf Coastal Lowlands, and on the north by the valley of the Hillsborough and upper Withlacoochee rivers — and bounded on the east by the Lake Wales Ridge. Rising from the Polk Uplands surface are the Winter Haven and Lakeland ridges, and separating the upland from the DeSoto Plain on the south is an outfacing scarp. The Bone Valley formation underlies most of the Polk Upland as well as much of the adjacent DeSoto Plain to the south. The effects of solution in this area are not as intense as they are generally throughout peninsular Florida. The Peace, Manatee, Little Manatee, and Alafia rivers all head in the Polk Upland.

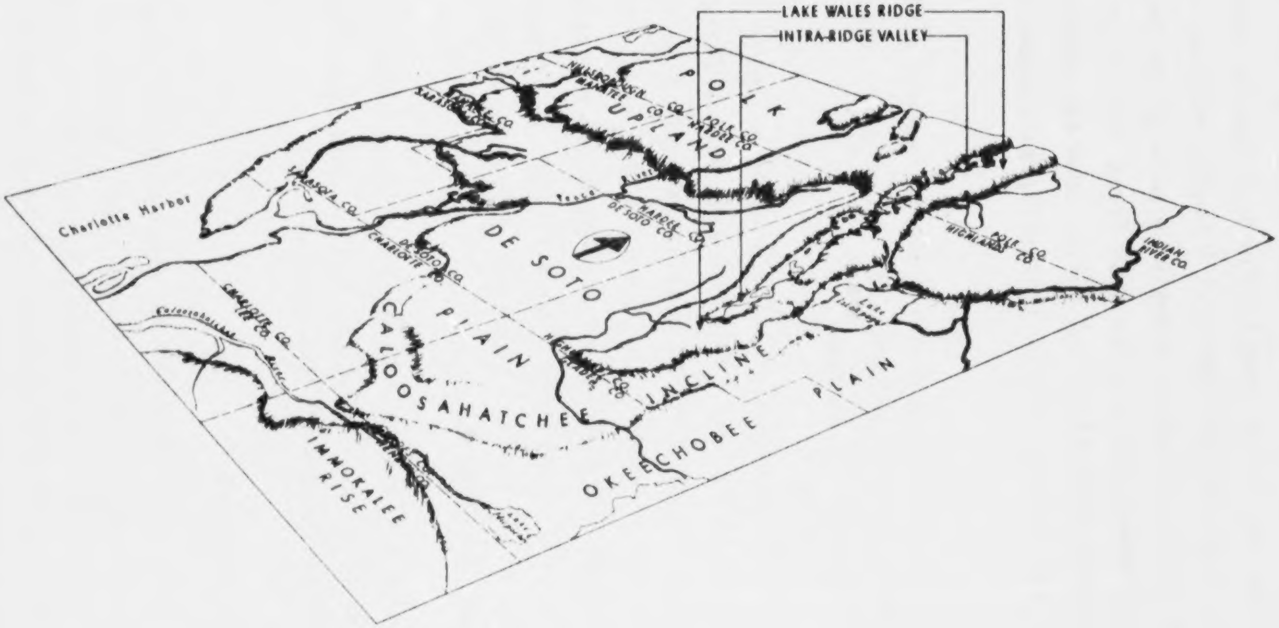

LAKE WALES RIDGE
INTRA-RIDGE VALLEY
POLK UPLAND
DE SOTO PLAIN
CALOOSAHATCHEE INCLINE
OKEECHOBEE PLAIN
IMMOKALEE RISE
Charlotte Harbor
HILLSBOROUGH CO.
MANATEE CO.
POLK CO.
HARDEE CO.
DE SOTO CO.
SARASOTA CO.
CHARLOTTE CO.
LEE CO.
HIGHLANDS CO.
INDIAN RIVER CO.

Figure 2.5. Topographic Features of Study Area (White 1970)

The relatively flat DeSoto Plain is bounded on the north by the Polk Upland, on the east by the Lake Wales Ridge, on the south by the Caloosahatchee incline, and on the west by the Gulf Coastal Lowlands. A line of swamps occurs in the southern extremeties. Probably marking the southern extension of the Bone Valley formation underlying much of the DeSoto Plain is the broad, gentle Caloosahatchee incline that forms much of the northern valley wall of the Caloosahatchee River and curves smoothly westward from the Lake Wales Ridge in a broadening fan of increasing gentleness of southward slope.

The Okeechobee Plain begins its southern descent at the southern end of the Osceola Plain and east of the Lake Wales Ridge, crossing one of the flattest parts of the United States.

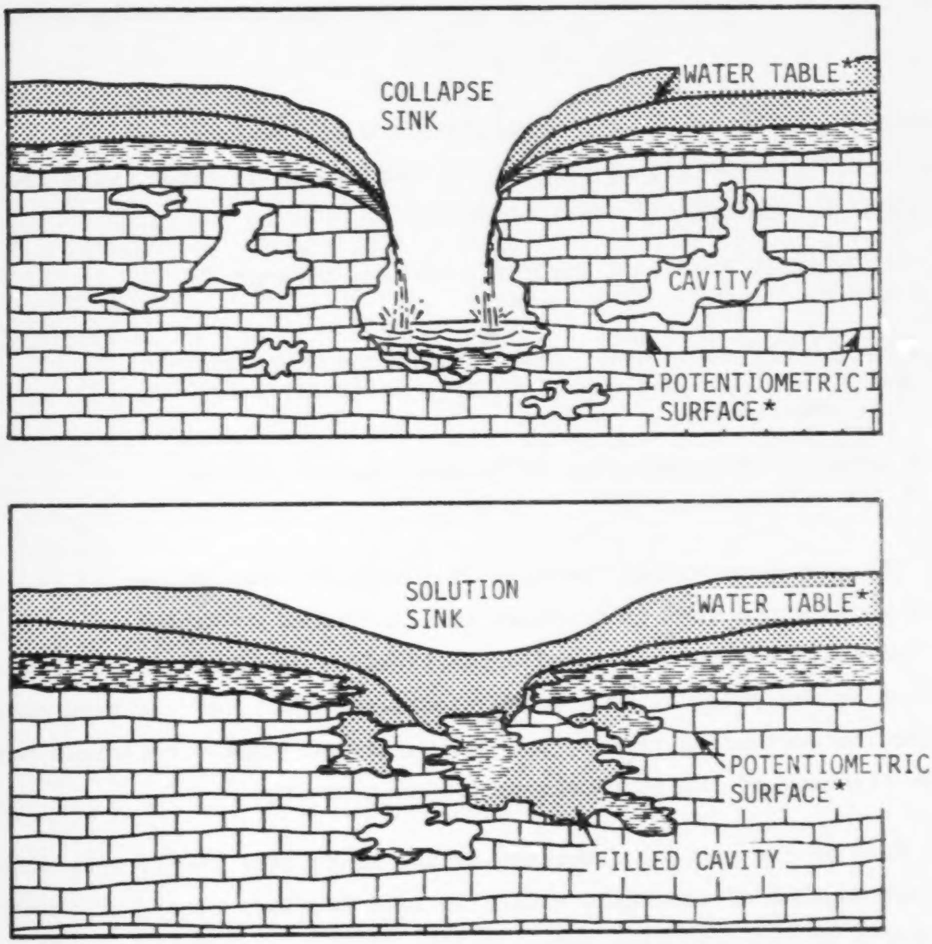
Linear belts or structural uplifts have been active in the study region since the mid-Tertiary; they bowed the Bone Valley formation after deposition, localized coarse phosphatic gravels in early Bone Valley time, and localized coarser clayey sands in late Bone Valley time. Subsequent renewal of uplift enlarged the ridges and accounted for the present-day sedimentation pattern being discordant with altitudes of presumed Pleistocene shorelines (Altschuler et al 1964) — hence the relationship between particle coarseness and surface elevation in the area.

The study area's topography is depicted at a scale of 1:250,000 and a contour interval of 15.24 meters (50 feet) on the map (Plate 1) inserted in the pocket at the end of this document.

C. KARST (SINKHOLE) TOPOGRAPHY

Karst, or sinkhole, topography is characteristic of areas predominantly underlain by limestone, as is the study area. Karsts, or sinkholes, develop primarily because limestone is highly susceptible to solution weathering along lines of deposition (horizontal) and lines of fracturing (usually vertical). As it falls through the atmosphere and seeps through the highly organic topsoil, rainwater becomes weakly acidic and acts as a natural solvent to the limestone; the water then enters the rocks, following paths (channels) of least resistance. Horizontal, generally interconnected caverns develop as the channels continue to grow. Sinkholes develop when the caverns enlarge until the overlying sediments can no longer be supported.

Wright (1974) recognizes two distinct types of sinkholes: the collapse sink and the solution sink (Figure 2.6). There are other investigators who recognize three distinct types: Wright's (1974) collapse sink and solution sink plus the erosion sink. The latter, however, appears to be applied to the development processes in which the culmination is either a collapse sink or a solution sink.


COLLAPSE SINK
WATER TABLE*
CAVITY
POTENTIOMETRIC SURFACE*
SOLUTION SINK
WATER TABLE*
POTENTIOMETRIC SURFACE*
FILLED CAVITY

*Defined and discussed in Volume V.

Figure 2.6. Generalized Diagram of Sinkhole Characteristics (Wright 1974)

According to Wright (1974), collapse sinks are produced by collapse of the limestone roof above an underground void, and solution sinks are developed slowly downward by dissolution beneath a soil mantle without rupture of the rocks in which they develop. Collapse sinks are normally steep-sided, rocky, and abruptly descending, and their formation is unpredictable and often instantaneous; thus, they constitute the greater threat to land development. Solution sinks may be funnel-shaped depressions broadly opened upward, or pan or bowl-shaped; they develop slowly and are usually preceded by formation of a radial fracture pattern in the soil or even in concrete or aspha[illegible] that might overlie them. The formation of solution sinks may not have as de[illegible]ating an effect as that of collapse sinks, but their occurrence can equally limit land use.

Sinkholes in the study area (the most probably regions being as depicted in Figure 2.7) may be either type, or a combination of types, with the following physical characteristics (Wright 1974):

- Permeable limestone in which dissolution by ground water has caused a cavity system
- A relatively thin layer of unconsolidated sediments, usually well drained and permeable, generally overlying the limestone
- A water table higher than the potentiometric surface of the artesian aquifer

The phosphate mining industry in the study area engages in two activities which would tend to increase the likelihood of sinkholes: dewatering the surface water table and upper Floridan aquifer* and stacking waste gypsum at the chemical processing plants.** Dewatered cavities provide less support to overburden layers, and the weight of stacked materials may exceed the strength of the sediments overlying a cavity.

Many of the natural fractures of the study area can be associated with the development of the Ocala uplift in late Tertiary time: it imparted heavy stresses to the overlying beds. Vernon (1951) recognized two main

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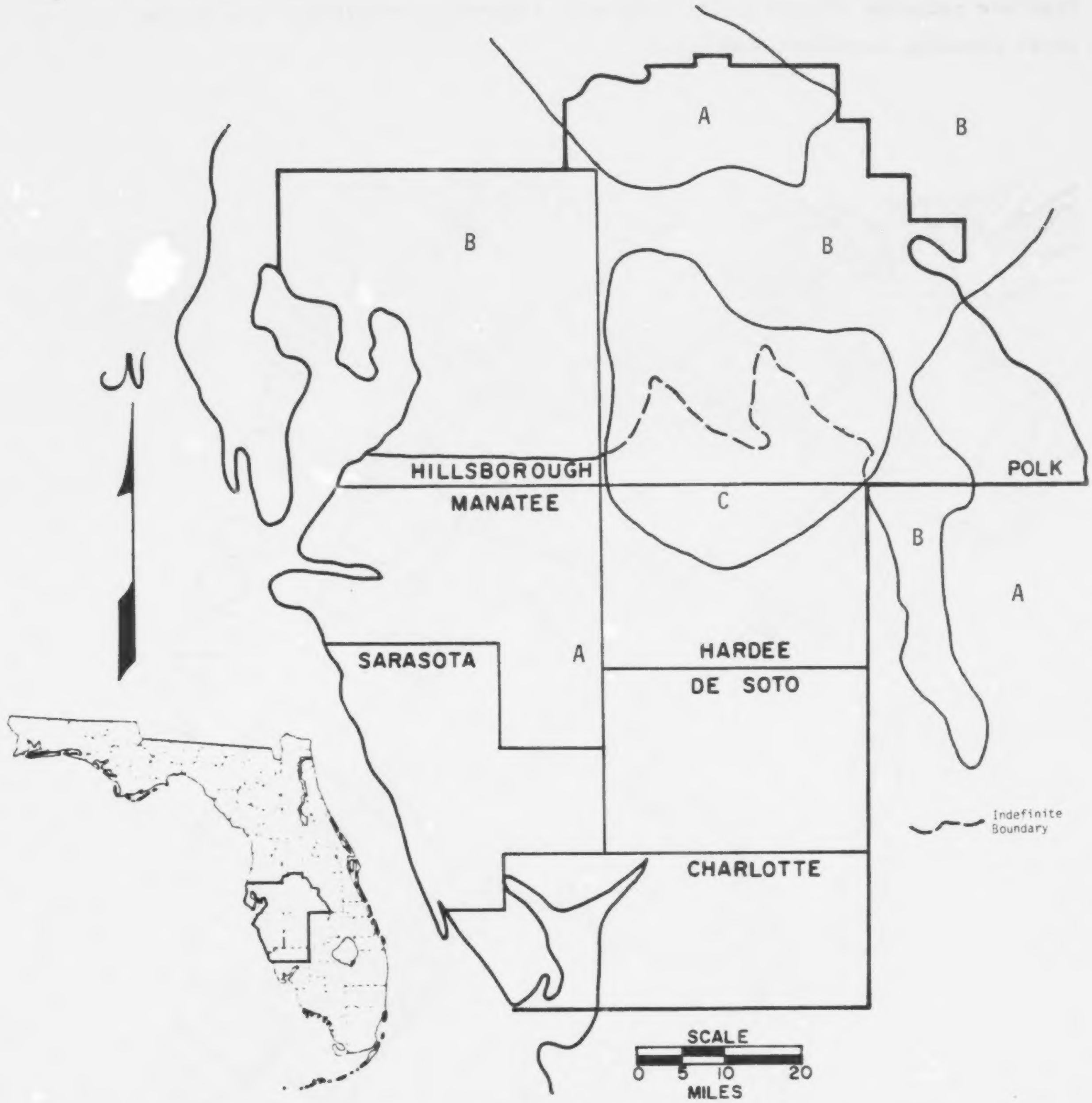
*See Volume V of this series.
**See Volume I of this series.


A
B
B
B
B
A
A
C
N
HILLSBOROUGH
POLK
MANATEE
SARASOTA
HARDEE
DE SOTO
CHARLOTTE
Indefinite Boundary
SCALE
0
5
10
20
MILES

A - Areas where peizometric surface is at or above land surface and/or thickness of clastic overburden exceeds 30 meters (100 feet). Appears to be least probable area for sinkhole development.

B - Area characterized by stable, prehistoric sinkholes, usually flat-bottomed, steep-sided, dry, or containing water. Modifications in geology and hydrology may activate process again.

C - Moderate to thick overburden overlying cavernous limestones. Sinkhole collapse dependent on local overburden thickness and level of water table.

Figure 2.7. Most Probable Sinkhole Regions in Study Area (Wright 1974)

fracture patterns (Figure 2.8): one with a northeast-southwest trend; the other trending northwest-southeast.

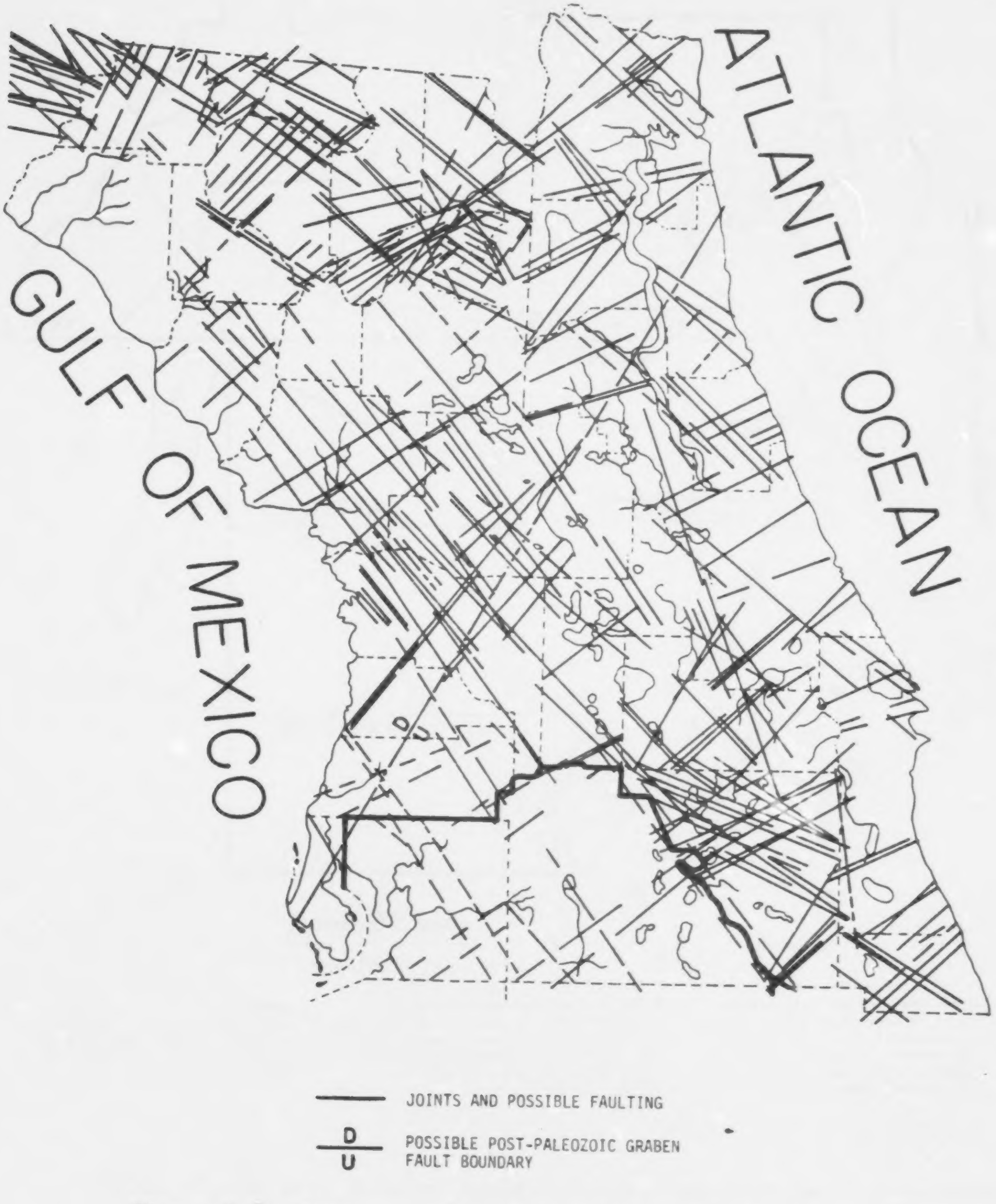

ATLANTIC OCEAN
GULF OF MEXICO
JOINTS AND POSSIBLE FAULTING
D
U
POSSIBLE POST-PALEOZOIC GRABEN FAULT BOUNDARY

Figure 2.8. Fracture Patterns of Northern Portion of Study Area and Northward (Vernon 1951)

D. SOILS

1. General

Soils result from the interaction of soil-forming processes on materials deposited or accumulated by geologic action. Soil characteristics at any given point are determined by:

- Type of parent material
- Climate under which the soil material accumulated and has existed since its accumulation
- Plant and animal life in and on the soil
- Topography or relief
- Length of time during which the forces of soil development have acted on the material

The type of parent material and the topography, or more accurately the degree of drainage, were the predominant factors in the formation of soil in the study area; except for alluvial deposits along the larger streams and organic deposits in wet areas, the soils developed on limestones, marls, and noncalcareous deposits of mixtures of sand, silt, and clay.

In a treatise on the sediments of the Floridian plateau, Cooke (1945) described the series of seven sandy formations which were deposited during seven different stages of sea level during the Pleistocene epoch of geologic time (see Table 2.4). Oscillations of sea level induced by the alternating formation and retreat of the great ice caps of the period also influenced the topography of the entire state. Many of the soils of the area were derived mainly from these sandy formations, which have been little altered since deposition. Thus, soils of the study area are generally sandy except in areas of low relief and poor drainage where peaty mucks are deposited.

The Coastal Lowlands of the study area are covered by somewhat poorly drained sands with an organic pan and are characterized by large, nearly level plains having numerous intermittent ponds, lakes, swamps, and marshes and scattered sinkholes in the northeastern part.

The Central Highlands — constituting portions of Polk, Hillsborough, Manatee, and Hardee counties — consist of physiographic features contributing to differential erosion that leaves residual remnants of former upland areas. These features are generally covered by well-drained sands, which exert strong influences on the type of soil found in the area. Relief and drainage are important factors, since gentle slopes are most favorable for the development of normal soils; i.e., the drainage is good, and the runoff is not excessive enough to be destructive to the formation of soil.

In summary, most of the soils of the study area are young and underdeveloped; nearly level or gently sloping; acidic; very sandy with high permeability; and generally low in clay, organic matter, and plant nutrients (Beckenbach 1973). Information concerning the mechanical and chemical properties of individual soils comprising a given soil association is, by definition, site-specific and not treated in this areawide study. Any existing detailed soil maps can be reviewed at the various county offices of the U.S. Soil Conservation Service. Information on the mechanical properties of specific soils can be obtained from the Soil Science Department of the University of Florida at Gainesville.

2. Distribution

Soil association boundaries (groupings of specific soil types that tend to characterize an area or constitute a pattern of specific parent material, drainage characteristics, or soil profile development characteristics) are defined in Plate 2 (in pocket). It should be noted, however, that within one soil association the soils may differ from each other in one or more of the primary soil properties (e.g., slope, color, depth); also, major soils of one association may be present in another association but in a different pattern and/or to a lesser extent. Where areas are large and planning is general, soil association mapping is valuable (and therefore appropriate for this study). Operations planning and site-specific studies would require more detailed soil mapping.

Each soil association mapped in Plate 2 is defined in Table 2.5, with the percentage of each within the study area indicated. They are grouped according to the four dominant drainage conditions of the study area; the group entitled "miscellaneous" land type contains unique soils (e.g., mine pits and dumps).

3. Associations

The general soil associations shown in Plate 2 have been rated for a number of selected uses, as indicated in Plate 5, and the following paragraphs interpret these ratings.*

a. Degree and Kind of Limitation Affecting Selected Uses

The behavior of the dominant soil under defined conditions is evaluated, and this is applied to the soil in its natural state. Slight means that soil properties are generally favorable for the stated use and that any limitations are minor and easily overcome. Moderate means that some soil properties are unfavorable but can be overcome or modified by special planning and design. Severe means that soil properties are so unfavorable and so difficult to correct or overcome that major soil reclamation, special designs, or intensive maintenance is required. These are not suitability ratings but actual measures of degree or intensity of soil limitations, restrictions, or hazards.

b. Water Management

Inherent features of soils within an association that affect water management are indicated for pond reservoir areas, drainage, and irrigation. Features and qualities affecting pond reservoir areas are permeability, depth to water table, depth to bedrock, or unfavorable factors that permit seepage, as well as soil slope, which influences storage potential and the stability of the embankment material. Drainage is affected by permeability, texture, and structure; stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage. Irrigation is

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*Refer to Florida Department of Administration (1975a and 1975b) for a more complete discussion of definitions.

Table 2.5. Soil Associations of Study Area (Page 1 of 2)*

Area Definition	Map Unit No. (% of study area)	Soil Association Description
Areas dominated by sandy droughty soils not subject to flooding	1 (1.6%)	Astatula-Arredondo association: Nearly level to sloping, excessively drained soils sandy throughout and well drained soils with very thick, sandy layers over loamy subsoil.
	17 (9.0%)	Astatula-Tavares-Basinger association: Nearly level to sloping, excessively and moderately well drained soils sandy throughout and poorly drained soils sandy throughout.
	24 (0.5%)	Candler-Tavares association: Nearly level to sloping, excessively drained soils with very thick, sandy layers over thin loamy or sandy loam lamella and moderately well drained soils sandy throughout.
Areas dominated by well-drained soils not subject to flooding	2 (0.7%)	Arredondo-Ft. Meade-Astatula association: Nearly level to sloping, well-drained soils with very thick, sandy layers over loamy subsoil and excessively drained soils sandy throughout.
Areas dominated by moderately well to poorly drained soils not subject to flooding	3 (2.1%)	Tavares-Adamsville association: Nearly level to gently sloping, moderately well and somewhat poorly drained soils sandy throughout.
	4 (2.8%)	Tavares-Myakka association: Nearly level to gently sloping, moderately well-drained soils sandy throughout and poorly drained sandy soils with weakly cemented sandy subsoil.
	5 (0.6%)	Pomello-St. Lucie association: Nearly level to sloping, moderately well-drained, sandy soils with weakly cemented sandy subsoil and excessively drained soils sandy throughout.
	6 (0.9%)	Sunniland-Bradenton association: Nearly level, somewhat poorly and poorly drained soils with thin, sandy layers over loamy subsoil underlain by marly material.
	7 (14.5%)	Myakka-Pomello-Basinger association: Nearly level, poorly and moderately well drained, sandy soils with weakly cemented sandy subsoil and poorly drained soils sandy throughout.
	8 (30.3%)	Myakka-Immokalee-Basinger association: Nearly level, poorly drained, sandy soils with weakly cemented sandy subsoil and poorly drained soils sandy throughout.
	9 (1.6%)	Ona-Myakka association: Nearly level, poorly drained, sandy soils with weakly cemented sandy subsoil.
	10 (0.1%)	Wabasso-Elred Oldsmar association: Nearly level, poorly drained, sandy soils with a weakly cemented sandy subsoil layer over loamy subsoil and poorly drained sandy soils with loamy subsoil.
	18 (1.2%)	Pomello-Basinger-St. Lucie association: Nearly level to gently sloping, moderately well-drained, sandy soils with weakly cemented sandy subsoil; poorly drained soils, sandy throughout; and excessively drained soils sandy throughout.
	19 (0.3%)	Myakka-Placid-Swamp association: Nearly level, poorly drained, sandy soils with weakly cemented sandy subsoil; very poorly drained soils, sandy throughout; and very poorly drained soils subject to prolonged flooding.
	20 (0.1%)	Felda-Pompano-Wabasso association: Nearly level, poorly drained, sandy soils with loamy subsoil; poorly drained soils sandy throughout; and poorly drained, sandy soils with a weakly cemented sandy subsoil layer over loamy subsoil.
	21 (0.1%)	Paisley-Bushnell association: Nearly level to gently sloping, poorly and somewhat poorly drained soils with thin sandy layers over clayey subsoil.
	25 (0.2%)	Pomello-Myakka-Tavares association: Nearly level to gently sloping, moderately well and poorly drained, sandy soils with weakly cemented sandy subsoil and moderately well-drained soils, sandy throughout.
	26 (3.9%)	Immokalee-Pomello association: Nearly level to gently sloping, poorly and moderately well-drained, sandy soils with weakly cemented sandy subsoil.
	27 (0.6%)	Wabasso-Felda association: Nearly level poorly drained, sandy soils with a weakly cemented sandy subsoil layer underlain by loamy subsoil and poorly drained, sandy soils with loamy subsoil.
	29 (0.3%)	Broward-Bradenton-Manatee association: Nearly level, poorly drained, sandy soils underlain by limestone; poorly drained soils with thin, sandy layers over loamy subsoil underlain by marly material; and very poorly drained, sandy soils with loamy subsoil.
	30 (0.8%	Wabasso-Bradenton-Myakka association: Nearly level, poorly drained, sandy soils with a weakly cemented sandy subsoil layer underlain by loamy subsoil; poorly drained soils with thin, sandy layers over loamy subsoil and poorly drained soils with weakly cemented sandy subsoil.
	35 (0.3%)	Pomello-Paola-St. Lucie association: Nearly level to sloping, moderately well-drained sandy soils with weakly cemented sandy subsoil and excessively drained soils, sandy throughout.
	36 (2.8%)	Immokalee-Myakka-Pompano association: Nearly level, poorly drained, sandy soils with weakly cemented sandy subsoil and poorly drained soils, sandy throughout.

Table 2.5. (Page 2 of 2)

Area Definition	Map Unit No. (% of study area)	Soil Association Description
	37 (5.9%)	Adamsville-Pompano association: Nearly level, somewhat poorly and poorly drained soils, sandy throughout.
	38 (0.2%)	Scranton, var.-Ona-Placid association: Nearly level, somewhat poorly drained, dark surface soils, sandy throughout; poorly drained soils with thin, sandy layers over weakly cemented sandy subsoil and very poorly drained soils, sandy throughout.
	40 (0.8%)	Pompano, high-Felda association: Nearly level, poorly drained, soils, sandy throughout and poorly drained, sandy soils with loamy subsoil.
	41 (0.1%)	Pompano, high-Pompano association: Nearly level, poorly drained soils, sandy throughout.
	43 (1.0%)	Bradenton-Wabasso-Felda association: Nearly level, poorly drained soils with thin, sandy layers over loamy subsoil; poorly drained, sandy soils with a weakly cemented sandy subsoil layer underlain by loamy subsoil and poorly drained, sandy soils with loamy subsoil.
	44 (0.2%)	Keri-Ft. Drum-Hallandale association: Nearly level, somewhat poorly drained soils with thin, sandy layers over loamy marl underlain by sand and poorly drained soils with thin, sandy layers over porous limestone.
Areas dominated by poorly and very poorly drained soils subject to flooding	11 (2.0%)	Basinger-Pompano-Swamp association: Nearly level, poorly drained soils, sandy throughout and very poorly drained soils subject to prolonged flooding.
	12 (0.3%)	Placid-Swamp association: Nearly level, very poorly drained soils, sandy throughout and very poorly drained soils subject to prolonged flooding.
	13 (0.2%)	Brighton-Terra Ceia association: Nearly level, very poorly drained, poorly decomposed, organic soils 132 cm (52 inches) or more thick and well decomposed, organic soils 132 cm (52 inches) or more thick.
	14 (4.3%)	Fresh Water, Swamp association: Nearly level, very poorly drained soils subject to prolonged flooding.
	15 (0.4%)	Salt Water Swamp and Marsh association: Nearly level, very poorly drained soils.
	22 (0.1%)	Chobee-Delray association: Nearly level, very poorly drained soils, loamy throughout and very poorly drained soils with thick, sandy layers over loamy subsoil.
	23 (0.6%)	Brighton-Placid association: Nearly level, very poorly drained, poorly decomposed organic soils 130 to 203 cm (51 to 80 inches) or more thick, and very poorly drained soils, sandy throughout.
	28 (1.5%)	Pompano-Charlotte-Delray association: Nearly level, poorly drained soils, sandy throughout and very poorly drained soils with thick, sandy layers over loamy subsoil.
	31 (1.0%)	Placid-Basinger association: Nearly level, very poorly and poorly drained soils, sandy throughout.
	32 (0.1%)	Delray-Manatee-Pompano association: Nearly level, very poorly drained soils with thick, sandy layers over loamy subsoil; very poorly drained, sandy soils with loamy subsoil and poorly drained soils, sandy throughout.
	33 (1.0%)	Fresh Water Swamp and Marsh association: Nearly level, very poorly drained soils subject to prolonged flooding.
	34 (1.8%)	Tidal Marsh and Swamp-Coastal Beach Ridges/Dune association: Nearly level, very poorly drained soils subject to frequent tidal flooding, high-lying coastal dune-like ridges and deep, droughty sands.
	39 (0.1%)	Terra Ceia association: Nearly level, very poorly drained, well-decomposed, organic soils 40 to 91 cm (16 to 36 inches) thick over loamy material.
	42 (0.4%)	Basinger-Placid association: Nearly level, poorly and very poorly drained soils, sandy throughout.
	45 (6.1%)	Felda-Manatee association: Nearly level, poorly drained, sandy soils with loamy subsoil and very poorly drained, sandy soils with loamy subsoil.
Miscellaneous land types	**16 (3.4%)**	**Mine pits and dumps**
Total	**100.8%**	(Error due to round-off.)

affected by slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumulations of salts and alkali; depth of the root zone; rate of water intake at the surface; permeability of soil layers below the surface layer; amount of water held available to plants; and need for drainage, or depth to water table or bedrock.

c. Suitability as Source of Topsoil, Sand, and Roadfill

Ratings as to suitability as source material for topsoil, sand, and roadfill are assigned to each soil association. Topsoil is used for topdressing and the establishment and maintenance of vegetation. Sand is considered in terms of use as a construction material and is rated good or fair if the thickness of the source is at least 0.9 meter (3 feet). Roadfill is soil material used to embank roads.

d. Potential for Agriculture

The agricultural potential of soil associations is rated as high, moderate, low, or very low, assuming that management practices include liberal applications of fertilizers and lime when needed and adequate water control. Limitations emanate from such factors as land preparation, drought, excess humus, excess salt, seepage, rapid percolation, poor outlets, productivity, tidal flooding, and excess moisture. Definitions of the capability unit designations that express the suitability for most kinds of field crops based on risks and potential response to management are as follows:

• Class I:	few limitations
• Class II:	moderate limitations that reduce choice of plants or that require moderate conservation
• Class III:	severe limitations that reduce choice of plants, require special conservation, or both
• Class IV:	very severe limitations that reduce choice of plants, require very careful management, or both
• Class V:	not likely to erode but having other limitations that are impractical to remove and thus limit use largely to pasture, range, woodland, or wildlife

Class VI:	severe limitations rendering a general unsuitability to cultivation and limiting use largely to pasture, range, or wildlife
Class VII:	very severe limitations rendering unsuitability to cultivation and restricting use largely to pasture or range, woodland, or wildlife
Class VIII	limitations precluding use for recreation, wildlife, water supply, or esthetic purposes

e. Suitability as Wildlife Habitat

The following soil properties affect the growth of wildlife habitat:

- Thickness and permeability
- Surface texture (stoniness or rockiness)
- Available water, moisture, and flood hazard
- Slope

SECTION 3

GEOCHEMICAL ENVIRONMENT

A. STRATIGRAPHY AND LITHOLOGY

The stratigraphy and lithology of the study area are summarized in Table 3.1 and diagrammed in Figure 3.1. Of importance to the phosphate industry is the lower Bone Valley formation of Pliocene age, which contains the matrix or ore zone that is mined as phosphate rock. Most of the world's production of phosphate rock comes from marine deposits, with the Bone Valley being a reworked marine deposit. Marine phosphate deposits are composed mainly of carbonate-fluorapatite in the form of fine crystals, structureless pellets, oolites, pisolites, nodules, and fossil remains, including those originally phosphatic (e.g., fish scales, teeth, shells) and those originally calcareous and now phosphatized. Other constituents associated with carbonate-fluorapatite are quartz, chert, hydromica and other silicates, carbonaceous matter, carbonates, and glauconite. As a group, phosphorite formations are thin (considering the geologic time that was required for their accumulation) and form only in the absence of significant deposition of clastic sediments or carbonates (McKelvey 1955).

Principal minerals in the commercially valuable phosphate deposits of the study area are those of the apatite group [mainly fluorapatite ($Ca_{10}(PO_4)_6F_2$) and the carbonate-apatites] and the aluminum phosphates [chiefly crandallite and wavellite, $Al_3(OH)_3(PO_4)_2 \cdot 5H_2O$]. Apatite's structural complexity favors many isomorphous substitutions. Thus, small amounts of oxides of vanadium, arsenic, silicon, and carbon (VO_4, AsO_4, SiO_4, and CO_3 and CO_4) may substitute for phosphorous (PO_4). The fluorine position in fluorapatite may be occupied by chlorine, forming chlorapatite, or by hydroxals, forming hydroxyapatite. Fluorapatite and hydroxyapatite may be CO_3-bearing and are called carbonate-hydroxyapatite and carbonate-fluorapatite. These anionic substitutions for PO_4 are electrostatically compensated by cationic substitutions of magnesium, manganese, strontium, lead, sodium, uranium, or rare earths. In crandallite, barium, strontium, rare earths, and uranium may substitute for Ca (calcium) and OH (hydroxyl) for PO_4. As indicated, uranium in phosphate

Table 3.1. Summary of Stratigraphy and Lithology of Study Area's Land-Pebble Phosphate District*

Age	Formation or deposit		Lithology: "Normal" Section	Lithology: Intensely weathered Section
Pleistocene or Recent	Pleistocene (?) sand or Residual sand mantle		Unconsolidated quartz sand, massive. Some organic material at surface. May have ground-water podsol. Overburden	Unconsolidated quartz sand, massive. Some organic material at surface. May have ground-water podsol. Overburden
			CONTACT LOWERED OR A WEATHERING BOUNDARY	CONTACT LOWERED OR A WEATHERING BOUNDARY
Pliocene	Bone Valley Formation	Upper Unit	Green clayey sand, minor apatite particles that are more abundant at base. Finely bedded, graded bedded, and crossbedded. Clay mineral, montmorillonite, weathered to kaolinite at top of unit. Overburden	White clayey sand, leached and indurated. Secondary aluminum phosphate minerals replacing clay and apatite. Clay is kaolinite. Basal layers may be vesicular, where the lower unit is altered. Aluminum phosphate alteration extends only partly into lower unit, but may replace parts of Hawthorn and Tampa Formations where they are close to the surface. Leached or Aluminum Phosphate Zone
			CONTACT GRADATIONAL	WEATHERING BOUNDARY
		Lower Unit	Phosphorite. Sand, clay, and gravel containing very abundant phosphate particles. Bedded, graded bedded, and crossbedded. Green, brown, and black. Matrix	Phosphorite, as in unweathered section. Matrix
			CONTACT UNCONFORMABLE	WEATHERING BOUNDARY
Miocene	Hawthorn Formation		Sandy, clayey, phosphate-bearing limestone. Dolomitic near surface. Buff, white, or cream. Contains interbedded sand, clay, or sandy clay. Bedrock	Residual calcareous, sandy clay, containing abundant phosphate particles; lower part grades into carbonate rock. Possible development of aluminum phosphate minerals, particularly in the northern part of the district, where the overlying formations are thin or absent. Bedclay
			CONTACT RELATIONS UNCERTAIN (CONFORMABLE TO SOUTH, DISCONFORMABLE TO NORTH)	CONTACT RELATIONS UNCERTAIN (CONFORMABLE TO SOUTH, DISCONFORMABLE TO NORTH)
	Tampa Limestone		Sandy and clayey limestone, contains chert nodules and trace amounts of phosphate. May form the bedrock in northern part of district. Tampa fossils reported from the Tenoroc mine.	Calcareous clay and sandy clay containing chert and phosphate. Aluminum phosphate minerals present when the formation is very close to the surface.
			CONTACT UNCONFORMABLE	
Oligocene	Suwannee Limestone		Limestone, contains minor sand and clay, but no phosphate. Chert present.	Secondary chert replacing limestone near the surface.
			CONTACT UNCONFORMABLE	
Eocene	Ocala Limestone		Very pure limestone.	Known only in subsurface.

*Altschuler et al 1964

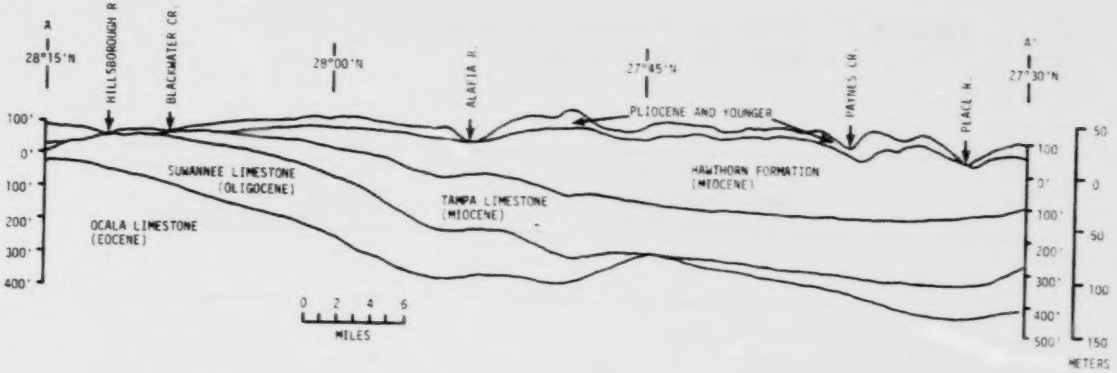
A
28°15'N
HILLSBOROUGH R.
BLACKWATER CR.
28°00'N
ALAFIA R.
27°45'N
PAYNES CR.
PEACE R.
A'
27°30'N
100'
0'
100'
200'
300'
400'
PLIOCENE AND YOUNGER
SUWANNEE LIMESTONE
(OLIGOCENE)
OCALA LIMESTONE
(EOCENE)
TAMPA LIMESTONE
(MIOCENE)
HAWTHORN FORMATION
(MIOCENE)
0 2 4 6
MILES
100'
0'
100'
200'
300'
400'
500'
50
0
50
100
150
METERS

Figure 3.1. Cross Section of General Structure and Stratigraphy through Portion of Study Area (Altschuler et al 1964) (Location of this section shown in Figure 2.2 of Section 2)

deposits occurs primarily in apatite or crandallite rather than in association with wavellite as has been reported (McKelvey 1955); it is in acid-soluble form, is tetravalent, and is believed to substitute isomorphously for calcium.

The aluminum phosphate deposits of the study area consist of crandallite, wavellite, or other aluminum-bearing phosphate minerals; kaolin clays; quartz sand; and perhaps some relatively unweathered remnants of unaltered minerals of the original deposits. The uranium content of aluminum phosphate deposits generally ranges from 0.01 to 0.03 percent but may be much higher locally. In this zone, uranium concentration is directly proportional to the concentration of calcium phosphate, i.e., the higher the calcium concentration, the higher the uranium concentration. In the Central Florida District, phosphorite particles in the Hawthorn limestone underlying the matrix zone contain 0.005 to 0.008 percent uranium; those in the overlying Bone Valley formation, derived in large part from marine reworked Hawthorn residuum, contain 0.01 to 0.02 percent (McKelvey 1955).

A typical commercial phosphate rock is usually a calcium phosphate containing 3-4 percent fluorine (Table 3.2), the major impurities being limonite or other iron oxides, clay, aluminum phosphates, and silica in the form of quartz sand. Commercial analyses of phosphate rock report P_2O_5 or tricalcium phosphate

Table 3.2. Chemical Analyses of Sedimentary Apatite, Bone Valley Formation*

	B. L.-3, Fine Pebble Bonny Lake Mine Ridgewood, Florida			Wa.-10, Pellets Watson Mine Fort Meade, Florida		
	1	2	3	1	2	3
Acid Inso.	-	6.6	-	-	2.4	-
CaO	49.5	-	52.9	51.5	-	52.7
P_2O_5	34.9	-	37.3	36.6	-	37.5
CO_2	2.1	2.0	2.2	1.9	1.7	1.9
SiO_2 (total)	6.7	-	-	2.9	-	-
SiO_2 (soluble)	-	0.8	0.9	-	1.1	1.1
SO_2	0.3	-	0.3	0.1	-	0.1
Al_2O_3	1.4	-	1.5	1.1	-	1.1
Fe_2O_3	0.4	-	0.4	0.9	-	0.9
Na_2O	0.1	-	0.1	0.2	-	0.2
K_2O	0.1	-	0.1	0.2	-	0.2
H_2O (+)	1.6	-	1.7	1.8	-	1.8
H_2O (-)	1.0	0.6	1.1	0.7	0.5	0.7
U	0.016	-	0.017	0.0075	-	0.0077
F	3.8	-	4.1	3.8	-	3.9
Total	101.9	-	102.6	101.7	-	102.1
F = O	1.6	-	1.7	1.6	-	1.6
Corrected total	100.3	-	100.9	100.1	-	100.5

1. Analysis by complete decomposition of sample by solution in HNO_3 and fusion of insoluble residue with Na_2CO_3.

2. Partial analyses of same material. Acid insoluble determined after boiling sample for 20 minutes with 1 + 3 HCl. Nonleachable carbonate determined after treatment in 0.5 M tri-ammonium citrate (Silverman, Fuyat, and Weiser, 1952).

3. Corrected analyses, free of insoluble residue. Microscopic examination and the two sets of SiO_2 figures establish that acid insoluble is essentially quartz.

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*Altschuler et al 1964

$Ca_3(PO_4)_2$ content, the latter often designated by the trade name BPL (bone phosphate of lime); iron and alumina as oxides, lime as CaO, and silica as insolubles.

B. ORIGIN OF PHOSPHATE ROCK IN STUDY AREA

The phosphate deposits of the land-pebble district of the study area are of complex derivation. They are thought to have originated by marine deposition of phosphates, followed by extensive reworking and alteration. Initially, deep phosphate-rich ocean waters upwelled along steeply inclined continental slopes into relatively shallow areas of the continental shelf made up of carbonate deposits; the upwelling of such deep water to shallow, more agitated, warmer zones caused loss of dissolved CO_2, an increase in pH, and supersaturation of phosphate and furthered the precipitation of apatite. The apatite tended to replace calcite ($CaCO_3$) in the weathering debris of the underlying formation; thus, a variety of nodules, pellets, and replacement casts were formed. Much later, after the Coastal Plain sediments had emerged, acidic waters mobilized the phosphate and carried it downward to sites where aluminum (Al^{3+}) and iron (Fe^{2+}) were concentrated; crystallization at this time produced wavellite, variscite [$Al(PO_4) \cdot 2H_2O$], and vivianite. Subsequent recrystallization and fluctuations in physical and chemical conditions increased crystal size and produced a variety of intergrowths and replacement textures (Adams 1972).

Nearly all investigators believe that the sea was the original source of the study area's phosphates, but there is evidence that the Florida deposits contain some reworked phosphorus of secondary terrestrial origin. It is suspected that ancient rivers created large deltas and that phosphorite was apparently deposited in shallow, restricted bays by deltaic redistribution. The phosphorite is associated with an absence of marine invertebrate fauna, indicating abnormal marine conditions (Bishop 1960). Important phosphate concentrating events such as acid water mobilization may have occurred during glacial events of the Pleistocene; sea level would have been lowered, as well as the water table in most places, thus creating a type of environment conducive to phosphate rock accumulation (Adams 1972). Deltaic rework of material also was probably glacial-related.

C. PRIMARY ZONATION OF MATERIALS

Figure 3.2 shows a typical section through the matrix or ore zone in the study area. The principal zones, in descending order are:

- Top soil or surface
- Overburden (excluding the aluminum phosphate zone which is considered overburden to phosphate mining)
- Leach or aluminum phosphate
- Matrix or calcium phosphate
- Bedclay
- Bedrock

Figure 3.3 shows the stratigraphic relations and lithology of these zones.

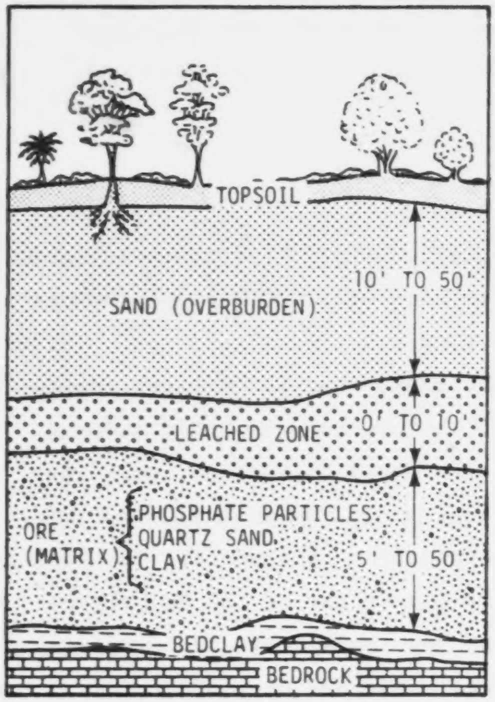

Figure 3.2. Typical Profile in Study Area (Fountain and Zellars 1972)

1. Top Soil (Surface) Zone

The top soil or surface zone within the study area exhibits somewhat well-developed soil characteristics dominated in their development by factors other than climate and vegetation; primarily, these factors include excessively poor drainage and unusual parent material. Additionally, these soils have been extensively modified locally by intensive agriculture.

The soil profiles that are predominantly developed on the poorly drained plains of the area exhibit eluviated quartz sand zones 0.3 to 0.6 meter (1 to 2 feet) thick immediately underlying the topmost zone of soil and grass. Under the eluviated sand zone, a zone heavily impregnated with translocated organic matter extends another 0.3 to 0.6 meter; beneath this zone, the clayey sands are being actively degraded by drainage through the overlying organic-rich layer. Total clay content is minimal just under the

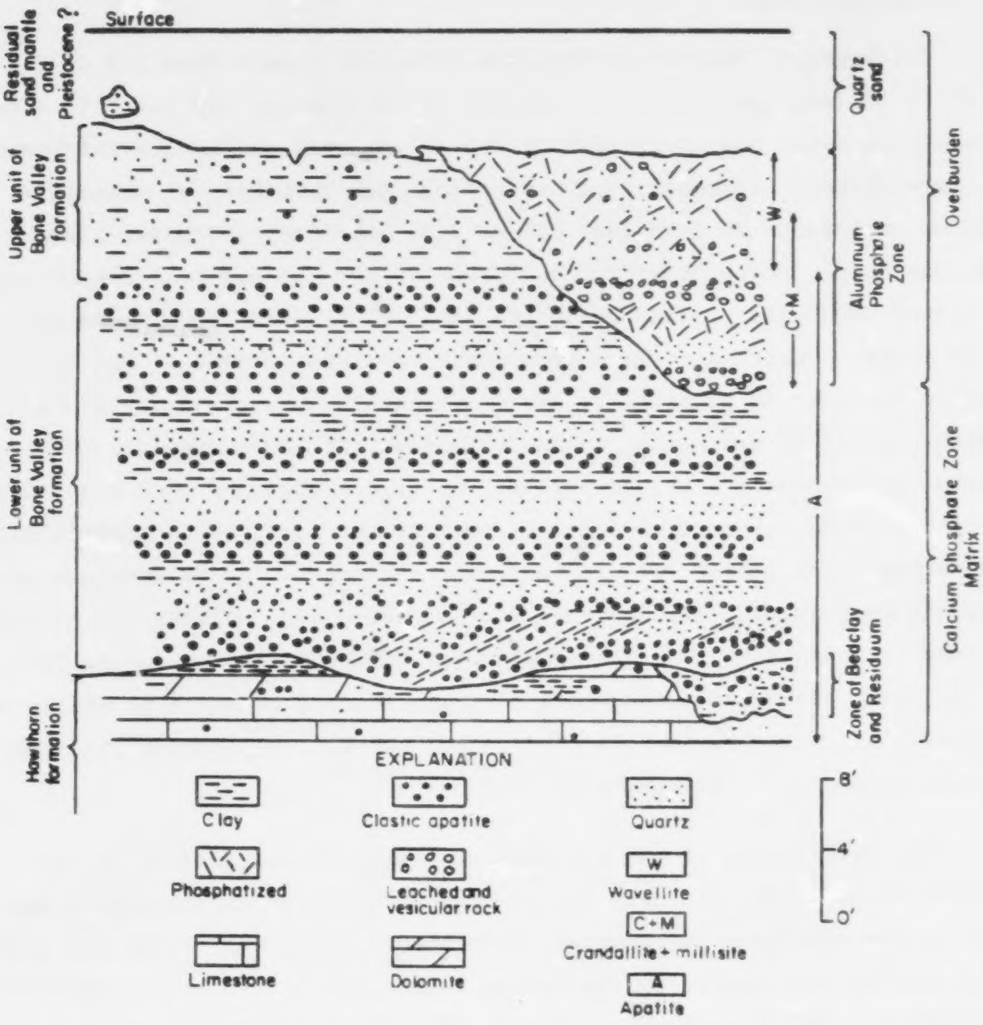
Surface
Residual sand mantle and Pleistocene ?
Upper unit of Bone Valley formation
Lower unit of Bone Valley formation
Hawthorn formation
Quartz sand
Aluminum Phosphate Zone
Overburden
Calcium phosphate Zone Matrix
Zone of Bedclay and Residuum
W
C+M
A
EXPLANATION
Clay
Clastic apatite
Quartz
Phosphatized
Leached and vesicular rock
Wavellite
Crandallite + millisite
Limestone
Dolomite
Apatite
8'
4'
0'

Figure 3.3. Stratigraphic Relations and Lithology of Primary Zones in Study Area (Altschuler et al 1964)

organic layer, and 0.3 meter or so below it is a zone in which clay pans and secondary iron concretions are deposited in previously weathered and iron-stained clayey sand. As the zonation is extended downward with continued degradation, the thickness of surmounting loose sand increases (Altschuler et al 1962).

2. Overburden Zone

Thickness of the overburden zone generally ranges from 1.5 to 9.1 meters (5 to 30 feet) but reaches a maximum of 18.3 meters (60 feet) in some portions of the area; the overburden thickness, as well as the ore thickness, results from primary sedimentation, weathering, and reworking of materials. Minerals of importance in this zone (Table 3.3) are quartz, montmorillonite, apatite, kaolinite, and vivianite (see Table 3.4 for the chemical composition of the listed materials), although quartz sand and altered clays predominate (60 to 70 percent quartz sand in a groundmass of clayey cement). The clay material in the zone is principally kaolinite, which is a postdepositional weathering product of underlying montmorillonite. The overburden is kaolinitic, even where not obviously altered; however, it grades downward into a montmorillonite zone (Altschuler et al 1962). Throughout the area, the montmorillonite is being subaerially transformed to kaolinite because of low-temperature supergene groundwater leaching of bases and silica, which also effects the release of any iron and magnesium. In the composition of its major components (SiO_2, Al_2O_3, and H_2O), the fully transformed clay is close to theoretical kaolinite; it is atypically rich, however, in Fe_2O_3, MgO, and K_2O, reflecting its montmorillonite progenitor (Altschuler et al 1964).

The development of the residual sand mantle (overburden) in the land-pebble field may be the most striking geomorphic and stratigraphic consequence of the supergene groundwater alteration. The clayey sands are made much more porous and friable by the volume losses incident to clay transformation (through interstitial water losses) and leaching and by loss of swelling property (the swelling properties of montmorillonite far exceed that of kaolinite). More voids are created by clay translocation, downward translocation, or downward physical removal. This process is evident both here and in the underlying leach zone in secondary clay cements called "cutans" which line floors of cavities, coat fractures, and build up minor clay hardpans throughout the weathered zone in the region. The combined effects of clay degradation and clay transformation ultimately create a completely eluviated quartz blanket over the region as part of the overburden. Where weathering has not grossly altered the montmorillonite, the overlying sands are thin (Altschuler et al 1962).

Table 3.3. Mineral Distribution in Study Area*

Quartz Accessories Residual patches of clay and apatite (m)*			Surface sands
Upper Bone Valley			Bone Valley Formation
Unleached	Leached and Altered		
Quartz	Quartz	Kaolinite	
Kaolinite (s)**	Crandallite	Gibbsite (tr)	
Montmorillonite	Wavellite	Attapulgite (tr)	
Apatite	Millisite	Manganese oxides (tr)	
Accessories (m)	Apatite	Accessories (m)	
Vivianite (m, s)			
Matrix zone			
Apatite Montmorillonite Quartz Chert (m) Accessories (m) Calcite (as constituent of pebbles at base)			
Bedclay zone			Hawthorn Formation
Attapulgite (s ?)	Quartz	Apatite	
Montmorillonite	Chert (s)	Dolomite (s ?)	
	Opal (s)	Calcite (m)	
Bedrock zone			
Montmorillonite	Quartz	Dolomite (s)	
Attapulgite	Chert	Calcite (m)	
	Opal (s)	Apatite (m)	
Deeper bedrock			
Montmorillonite	Quartz	Calcite	
	Chert	Dolomite (m, s ?)	
		Apatite (m)	

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*Altschuler et al 1964

**s = secondary; m = minor; tr = trace

Table 3.4. Chemical Composition of Important Minerals in Study Area

Mineral Name	Chemical Composition
Apatite	$Ca_5(F,Cl,OH)(PO_4)_3$
Kaolinite	$Al_2Si_2O_5(OH)_4$
Quartz	SiO_2
Vivianite	$Fe_3(PO_4)_2 \cdot 8H_2O$
Montmorillonite	$(Al,Mg)_8(Si_4O_{10})_3(OH)_{10} \cdot 12H_2O$
Millisite	$(NaK)CaAl_6(PO_4)_4(OH)_9 \cdot 3H_2O)$
Crandallite	$CaAl_3(PO_4)_2(OH)_5 \cdot H_2O$
Wavellite	$Al_3(OH)_3(PO_4)_2 \cdot 5H_2O$
Chert	SiO_2
Calcite	$CaCO_3$
Attapulgite	$(Mg,Al,Fe)_5(Al,Si)_6O_{20}(OH)_2 \cdot 8H_2O$
Dolomite	$CaMg(CO_3)_2$

3. Leach Zone

The leach zone, also referred to as the aluminum phosphate zone, is a discontinuous zone of altered friable phosphatic sandstone considered to be a part of the upper Bone Valley formation and varying in thickness from 0.3 to 3.3 meters (1 to 10 feet). In mines in the Peace and Alafia drainage basins, the upper Bone Valley section is irregularly transgressed by a white zone of leaching and alteration in which the rock has become vesicular, friable, or indurated and is very light in weight. The leach, or aluminum phosphate, zone is composed of quartz sand cemented and indurated by the secondary minerals wavellite, crandallite, and (locally) millisite. Apatite and kaolinite also exist to the virtual exclusion of montmorillinite (see Table 3.3). Since millisite requires alkalies, it is restricted in occurrence and is probably related to the distribution of montmorillonite. In most areas where montmorillonite has been transformed to kaolinite before the phosphatization of clay, crandallite has developed rather than millisite.

Also occurring within the leached zone is fine-grained secondary cement composed of kaolinite and the aluminum phosphate minerals. There is indication of its deposition from descending solutions from which phosphate minerals were precipitating and of kaolinite being reformed from solution or being redeposited from suspension. More alumina replacement occurs with continuation of alteration (Altschuler et al 1955).

At the base of the leach zone, carbonate-fluorapatite and clay still occur, though both are incipiently leached and altered. Cavity fillings are microscopic, and secondary cements occur only as fracture fillings and coatings around partly leached grains. These secondary cements include chert (SiO_2) and apatite and limonite [$FeO(OH) \cdot nH_2O + Fe_2O_3 \cdot nH_2O$] and underlie the aluminum phosphate zone in the form of discontinuous seams of hardpan cementing porous sands and encrusting the upper surfaces of clay. The hardpans are a sample of the movable materials removed from the overlying leach zone by acid ground waters and deposited in the unleached zone below (matrix) where basic calcium phosphates neutralize the ground water. The clay sequence from the base to the top of the Bone Valley formation varies from pure montmorillonite to montmorillonite plus kaolinite to pure kaolinite, and the basal clays contain iron-rich montmorillonite and limonite.

Higher in the leach zone, pebbles are absent but cavities display an original pebbly texture. Secondary cements, primarily in the form of layered cavity fillings, may constitute 10 percent of the rock. Toward the top of the zone, leaching is most pronounced and secondary cements diminish. In the uppermost few inches, a sharp increase in cement content underlies the boundary with the loose sands (herein referred to as overburden) and probably represents a caliche deposited during occasional periods of extreme dryness.

The uranium content of the leached zone (between 0.01 and 0.03 percent) is higher than that exhibited by either the overburden above (typically, 0.002 to 0.003 percent uranium) or the matrix below (between 0.019 percent for low-grade phosphate deposits to 0.012 percent for high-grade deposits) (Altschuler et al 1955 and 1962).

Altschuler et al (1955) conducted chemical analyses of several samples ranging from the lower part of the leach zone to the upper part. Results appear in Table 3.5.

Distinctive features of the aluminum phosphate zone can be summarized as follows (Altschuler et al 1955):

- The zone transgresses the stratigraphy and always extends downward from the top of the Bone Valley formation.
- The zone is commonly underlain by hardpans reflecting old groundwater levels.
- The mineralogic and textural changes progress vertically through the section and diminish downward.
- The zone is characterized by leaching and reprecipitation involving depletion of CaO, Na_2O, silica, and some phosphate and the complementary increase in Al_2O_3 coordinated as acid aluminum phosphates that yield downward to basic calcium phosphates.

4. Matrix Zone

The matrix zone, also referred to as the calcium phosphate zone, consists of the lower part of the Bone Valley formation and the economic part of the residual Hawthorn formation. Mineral occurrences in the zone are apatite, montmorillonite, quartz, chert, and calcite (Table 3.3) as constituents of the pebbles near the base of the zone. The zone's thickness ranges from 0 to 15.2 meters (0 to 50 feet) and averages about 3.7 meters (12 feet); the thickest deposits are commonly in depressions on the eroded Hawthorn surface. The matrix is an unconsolidated mixture of phosphate pellets and granules (concentrate) and cobbles and boulders (pebbles) of phosphatized limestone, quartz sand, silt, and clay; in currently mined areas, it consists of about equal parts of recoverable

Table 3.5. Chemical Analyses of Seven Samples from Profile through Aluminum Phosphate Zone[*]

	Lower →						→ Upper
Constituent	Ho-20	Ho-20A	Ho-21	Ho-22	Ho-23	Ho-24	Ho-25
SiO_2	51.48	62.60	40.92	57.24	69.46	68.08	51.32
Al_2O_3	8.26	5.98	12.48	14.17	8.16	9.40	14.91
Fe_2O_3[**]	2.76	2.86	2.61	2.17	1.32	1.33	2.19
MnO	0.70	0.53	2.14	0.16	0.16	0.14	0.13
MgO	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CaO	8.98	8.25	8.00	3.10	0.90	0.20	1.20
Na_2O	0.23	0.13	0.12	0.15	0.06	0.04	0.03
K_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TiO_2	0.37	0.40	0.63	0.63	0.31	0.42	0.65
P_2O_5	19.72	13.60	20.79	12.79	11.61	11.32	16.35
Loss on ignition[***]	6.76	6.09	11.72	9.96	7.91	9.18	13.24
CO_2	0.80	0.24	0.26	0.05	0.02	0.02	0.05
F	1.15	0.52	0.63	0.59	0.51	0.70	0.53
Cl	0.03	0.02	0.04	0.01	0.03	0.02	0.01
SO_3[†]	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cr_2O_3	0.01	0.01	0.01	0.01	0.01	0.01	0.01
V_2O_5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U[‡]	0.01	0.03	0.02	0.01	0.01	0.01	0.01
Total	101.28	101.28	100.39	101.06	100.49	100.89	100.65
Less F = O	0.48	0.22	0.27	0.25	0.22	0.30	0.22
Less Cl = O	0.01	0.01	0.01	0.00	0.01	0.01	0.00
Corrected total	100.79	101.05	100.11	100.81	100.26	100.58	100.43
H_2O (110°C)	0.35	0.49	1.13	0.64	0.73	0.39	0.88

[*] Altschuler et al 1955

[**] Total iron, some of which may be present as ferrous iron.

[***] Includes adsorbed water (H_2O) and excludes CO_2.

[†] Represents total sulfur; no sulfides found.

[‡] Reported as a metal, since its valence state was not determined.

phosphate particles (pebble and concentrate), quartz sand (tailings), and clay (slime). The chemistry of these fractions is indicated in Table 3.6, and a chemical analysis of the montmorillonite clay that predominates the zone is presented in Table 3.7.

Table 3.6. Chemical Analysis of Commercial "Pebble" and Concentrate from Study Area*

Element	"Pebble"	Concentrate
CaO	46.98	49.76
MgO	0.19	0.29
MnO	0.048	0.044
K_2O	0.13	0.10
Na_2O	0.21	0.24
P_2O_5	32.07	34.21
V_2O_3	0.014	0.010
As_2O_3	0.0011	0.0014
CO_2	3.07	2.59
SO_3	0.59	0.52
SiO_2	9.31	5.68
Al_2O_3	1.29	0.95
Fe_2O_3	1.57	1.31
TiO_2	0.076	0.105
Cr_2O_3	0.007	0.007
U_3O_8	0.018	0.010
F	3.68	3.81
Cl	0.013	0.014
H_2O	1.88	1.52
Organic	0.053	-
CaO/P_2O_5	1.465	1.455
F/P_2O_5	0.115	0.111

*Altschuler et al 1964.

The compositional differences between "pebble" and concentrate are significant: the pebble fraction is consistently lower in P_2O_5. This chemical variation is due principally to differences in content and nature of diluting inclusions: in pebble from residually enriched Hawthorn deposits, calcite is an important diluent; in the Bone Valley formation, the principal diluent is silt-size quartz. The content of Fe_2O_3 and Al_2O_3 (reported together as percent "I and A" in production analysis) is consistently between 2 and 4 percent in both the pebble and concentrate fractions, the exception being the weathered upper part of the section where the Al_2O_3 content may be very high.

Although the abundances of most of the minor elements in phosphorites do not differ greatly in pebble and concentrate fractions, some small differences may be significant. One notable example is the consistently higher uranium content of the pebble fraction in any single deposit (Altschuler et al 1964). Average matrix contains approximately 0.008 percent U_3O_8: the pebble fraction between 0.008 and 0.05 percent, the slime fraction approximately 0.005

percent, the tailings fraction less than 0.001 percent, and the concentrate between 0.004 and 0.03 percent (Cathcart 1955).

Cannon et al (1976) conducted comparative analyses of five samples of the matrix zone in order to study a matrix calcination-digestion process and summarized the samples (located as points A through E in Figure 2.2, page 6) as follows:

- Sample A

  This sample is representative of the older mining operations in the northern section of the phosphate field which, because of its high phosphate content, has been mined very intensively. Its clay content is primarily kaolinite. The sample contains an above-average amount (87 percent) of material smaller than 1.5 millimeters (0.06 inch) and larger than 0.1 millimeter (0.004 inch), which normally is used as flotation feed.*

Table 3.7. Chemical Analysis of Montmorillonite Clays, Bone Valley Formation, Saddle Creek, Florida*

Constituent	%
SiO_2	56.91
TiO_2	0.65
Al_2O_3	22.65
Fe_2O_3	6.29
FeO	0.11
MgO	3.62
CaO	1.47
Na_2O	0.18
K_2O	0.74
Li_2O	0.03
H_2O +	7.34
Total	99.99

*Altschuler et al 1964

**Analyses were made of clay fractions (-2μ) settled from clay containing quartz, apatite, and accessory minerals. Analyses have been corrected for identified apatite and crandallite after chemical determination of leachable P_2O_5, CaO, and Al_2O_3.

Sample: montmorillonite, basal part of the formation.

- Sample B

  This sample originates in the southwestern location of the phosphate field and represents the newer mining areas toward Manatee County. The matrix has a more typical distribution of apatite, sand, and clay and a high pebble content, which contains an iron impurity in solid solution. The sand fraction is present in rather coarse form. Most of the clay is a mixture of montmorillonite, attapulgite, and kaolinite.

- Sample C

  Except for weathering, this sample is quite similar to Sample B. It originates in a mine located in the lateritic weathering belt; consequently, about half of the pebble shows strong weathering. The clay fraction consists almost exclusively of montmorillonite and constitutes about one-third of the matrix. The sand fraction contains both coarse and fine sand.

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*This and other terms such as "slime" and "tailings" are defined in Volume I.

- Sample D

  This sample contains primarily attapulgite clay. The mine from which it originates is located near the southeastern end of the lateritic weathering belt; the weathering is evident primarily in the flotation feed fraction. Since the sample contains 70 percent clay, it cannot be considered a representative matrix sample.

- Sample E

  This sample is a high-quartzite high-aluminum matrix with very little pebble phosphate. Its clay content, being nearly all montmorillonite, is about average for the area. There is a substantial amount of aluminum in minerals other than clay.

5. Bedclay Zone

Underlying the matrix zone is a thin discontinuous deposit of soft water-saturated plastic sandy clay that grades into the dolomitic material below and is mined where the residual concentration of phosphate particles and the P_2O_5 content of the particles are economically significant. Often, this bedclay has more uranium (0.002 to 0.015 percent U_3O_8 with an average of 0.005 percent) than does the minable material directly above it (Cathcart 1955).

Other minerals of the bedclay zone include attapulgite, montmorillonite, quartz, and dolomite (Altschuler et al 1964). Since the bedclay zone is predominantly montmorillonite, its chemistry is essentially consistent with that presented in Table 3.7.

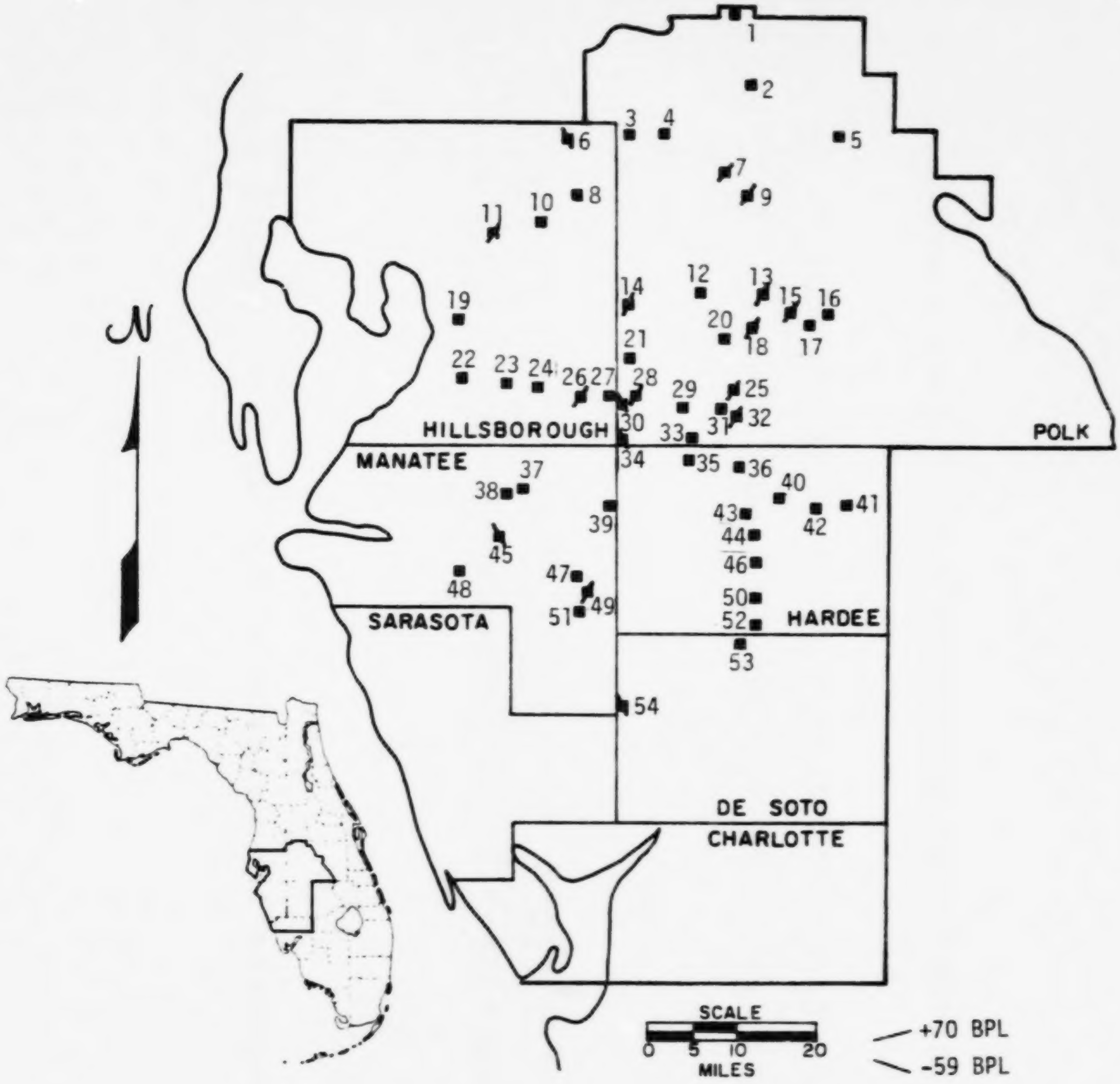
6. Bedrock Zone

In the land pebble district, the bedrock zone is the Hawthorn formation, which underlies most of the Bone Valley formation. The uppermost Hawthorn is composed of fine-grained sandy and marly dolomite [$CaMg(CO_3)_2$] as well as dolomitic sands and marls, all sparsely phosphatic. The clay mineral that predominates in the upper Hawthorn is montmorillonite; it grades upward to attapulgite. The chemistry of the bedrock zone is not quantitatively discussed in this document.

7. Overburden and Matrix Thickness

Overburden and matrix thickness is highly variable over the 7-county study area, as dictated by the ancient topographic surface of the underlying

Hawthorn formation and the local topography of the current surface. Overburden thickness here, including the leach zone, matrix thickness, and BPL content of the matrix at selected sites in the area (Figure 3.4), are detailed in Table 3.8.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POLK
MANATEE
SARASOTA
HARDEE
DE SOTO
CHARLOTTE
N
SCALE
0
5
10
20
MILES
+70 BPL
-59 BPL

Figure 3.4. Data-Point Locations for Overburden and Matrix Thickness and BPL Data of Table 3.8

Table 3.8. Overburden and Matrix Thickness and Matrix BPL Content at Selected Locations in Study Area

Location Number	Thickness of Overburden in Meters (Feet)	Thickness of Matrix in Meters (Feet)	BPL Content
1	10.7 (35)	0.9 (3)	64
2	17.4 (57)	4.0 (13)	63
3	10.7 (35)	4.9 (16)	--
4	10.4 (34)	4.0 (13)	66
5	17.1 (56)	3.7 (12)	64
6	1.2 (4)	4.3 (14)	40
7	6.1-12.2 (20-40)	1.5-4.6 (5-15)	70
8	2.1 (7)	3.0 (10)	--
9	12.8 (42)	2.4 (8)	75
10	6.7 (22)	5.5 (18)	--
11	7.0 (23)	0.3 (1)	79
12	16.2 (53)	4.6 (15)	68
13	16.2 (53)	2.1 (7)	72
14	6.1 (20)	4.6 (15)	70
15	19.5 (64)	3.7 (12)	74
16	21.3 (70)	3.7 (12)	63
17	25.9 (85)	4.9 (16)	65
18	8.5 (28)	6.1 (20)	72
19	6.1 (20)	4.9 (16)	--
20	6.7 (22)	5.5 (18)	69
21	8.5 (28)	6.1 (20)	68
22	7.0 (23)	3.0 (10)	66
23	17.1 (56)	4.9 (16)	--
24	10.7 (35)	2.4 (8)	62
25	6.1 (20)	4.6 (15)	70
26	7.3 (24)	5.5 (18)	70
27	7.3 (24)	3.4 (11.2)	--
28	7.3 (24)	3.7 (12)	70
29	6.4 (21)	5.8 (19)	68
30	7.9 (26)	4.6 (15)	--
31	7.6 (25)	5.5 (18)	68
32	15.2 (50)	4.6 (15)	73
33	5.5-17.7 (18-58)	3.7 (12)	68
34	10.7-13.7 (3.5-4.5)	9.1-12.2 (30-40)	58
35	17.7 (58)	3.7 (12)	68
36	6.7 (22)	3.0 (10)	66
37	12.5 (41)	7.6 (25)	62
38	17.7 (58)	3.7 (12)	--
39	6.1 (20)	7.6 (25)	--
40	3.7 (12)	0 (0)	--
41	10.7 (35)	6.1 (20)	63
42	12.5 (41)	2.4 (8)	--
43	7.9 (26)	6.4 (21)	66
44	7.0 (23)	4.0 (13)	68
45	12.2 (40)	14.3 (47)	55
46	4.6 (15)	2.4 (8)	69
47	12.5-15.2 (40-50)	9.1-12.2 (30-40)	60±
48	13.7 (45)	6.1 (20)	60
49	31.7 (45)	2.4 (8)	70
50	8.5 (28)	3.0 (10)	62
51	15.9 (52)	6.1 (20)	65
52	8.2 (27)	3.0 (10)	63
53	7.6 (25)	1.5 (5)	65
54	4.6-6.1 (15-20)	3.0-6.1 (10-20)	55

SECTION 4

RADIATION ENVIRONMENT

A. INTRODUCTION

Ionizing radiation is ubiquitous to man's environment, originating from the sun and other celestial bodies, naturally occurring earth materials, and even man-made materials. Because radiation can impact man's existence, there has been much study to identify and quantify the various aspects of both the natural and man-made radiation environments of man; however, much is still unknown.

One aspect germane to the study of the phosphate industry in central Florida is man's actions that redistribute naturally occurring radioactive source materials in the biosphere. There have been specific studies of naturally occurring ionizing radiation in Florida (e.g., Osmond 1964) and the actions of the phosphate industry (e.g., Mills et al 1977) in an attempt to determine the scope of industry's modification of the natural radiation environment of the 7-county study area. Recent works of importance on the interrelationships of the phosphate industry and the area's radiation environment include:

- Effects of Phosphate Mineralization and the Phosphate Industry on Radium-226 in Ground Water of Central Florida, USEPA, Office of Radiation Programs, Las Vegas Facility, October 1977
- Occupational Radiation Exposure in the Florida Phosphate Industry, a status report submitted to the Florida Phosphate Council by the College of Engineering, University of Florida, Gainesville, Florida, March 29, 1977
- Natural Radiation Exposure Assessment, Radioactivity of Lands and Associated Structures, a semiannual technical report submitted to the Florida Phosphate Council by the University of Florida, Gainesville, Florida, 1977
- Study of Radon Daughter Concentrations in Structures in Polk and Hillsborough Counties, final report, Florida Department of Health and Rehabilitative Services, November 15, 1977

The world's primary phosphate occurrences are of sedimentary origin and contain radioactive materials, predominantly uranium and its decay products. Uranium, along with a very small amount of thorium, is thought to have been deposited contemporaneously with the phosphate. (See Section 3 of this volume.) The phosphate deposits of the study area contain uranium concentrations of between 0.01 and 0.02 percent, whereas ores mined in the western United States solely for their uranium content contain 10 to 20 times this concentration. However, the phosphate industry currently mines slightly more total uranium than does the uranium industry (Guimond 1976a).

The naturally occurring radioisotopes uranium-238 (99.3 percent of the natural uranium) and thorium-232 (effectively 100 percent of natural thorium) are both long-lived radiation emitters and parents of radioactive decay chains that contribute, along with potassium-40, practically all the natural environmental radiation of terrestrial origin (University of Chicago 1964). (The remaining 0.7 percent of naturally occurring uranium is the radioisotope uranium-235.) Potassium-40 shows little affinity for ionic substitution in fluorapitite and thus is found only in minute quantities in marine phosphate deposits; it also comprises only 0.00119 percent of naturally occurring potassium (Wollenberg and Smith 1964). Thorium-232, although existing in much higher concentrations in such deposits, is still in quantities considerably less than those of natural uranium. Guimond (1977) shows that thorium-232 radioactivity concentrations in marketable phosphate rock from the study area are two orders of magnitude less than those of natural uranium. Habashi (1966), in using scintillation spectrometry to study radioactivity in phosphate rock, detected no peaks due to thorium or its decay products in phosphate rock samples from Florida, indicating the virtual absence of this particular radionuclide in the samples studied. Uranium and thorium for the most part are highly insoluble in ground water, but the uranium ion, in contrast to the thorium ion, is better able to form complex ions that are soluble and thus subject to leaching from host rocks.

Normally, radioactive materials in phosphates are confined at a depth at which their impact on man and his immediate environment is mitigated. However, the mining, processing, and transporting of phosphate ores and their derived products containing small concentrations of radioactive materials expose the local population to potential radiation hazards above those they would encounter had these activities been absent. Mills (1974) states four potential ways in which individuals and the population in general are exposed to these materials by the acts of phosphate mining, processing, product manufacturing, and product use:

- Air-gases and particles

  Gaseous and particulate radioactive materials are released to the air, posing the possibility of inhalation and decreasing overall air quality.

- Water-effluents, runoff, and leaching from wastes

  The radioactive materials in the ores or the products can enter ground waters, rivers, and other water bodies through effluent discharges, land runoff, and leaching from waste piles.

- Direct contact

  Direct contact or close proximity to the radioactive materials directly exposes workers, individuals, and the population.

- Food chain

  Because of the application of phosphate fertilizers, the food chain can become contaminated and result in man's ingestion of radioactive materials.

The remainder of this section discusses these exposure paths and presents information concerning the radiation environment of the study area derived primarily from studies by the United States Environmental Protection Agency and supported by general technical literature.

1. Radioactive Decay of Uranium

Radioactivity of terrestrial origin in the study area can be traced predominantly to the existence of small amounts (generally 200 parts per million or less) of uranium in the phosphate deposits of the area. This radioactive material decays naturally to other radioactive materials in a chain (or series) in its progression toward a stable or nonradioactive state. For example, the stable endpoint for uranium-238 is lead with a mass number of 206 (Table 4.1). The intermediate materials or radioactive nuclides, of which there are 13, are called daughters and are identified by the element name followed by its mass number (e.g., radium-226).

Table 4.1. Uranium-238 Decay Series*

Isotope	Symbol	Historical Name	Half-life	Radiation	Energy in MeV (% emission)
Uranium-238	$_{92}U^{238}$	Uranium I	4.5×10^{9} yr.	α	4.18(77), 4.13(23)
Thorium-234	$_{90}Th^{234}$	Uranium X_1	24.1 day	β	0.19(65), 0.10(35)
				γ	0.09(15), 0.06(7), 0.03(7)
Protactinium-234	$_{91}Pa^{234}$	Uranium X_2	1.18 min.	β	2.31(93), 1.45(6), 0.55(1)
				γ	1.01(2), 0.77(1), 0.04(3)
Uranium-234	$_{92}U^{234}$	Uranium II	2.50×10^{5} yr.	α	4.77(72), 4.72(28)
				γ	0.05(28)
Thorium-230	$_{90}Th^{230}$	Ionium	8.0×10^{4} yr.	α	4.68(76), 4.62(24)
Radium-226	$_{88}Ra^{226}$	Radium	1622 yr.	α	4.78(94), 4.59(6)
				γ	0.19(4)
Radon-222	$_{86}Rn^{222}$	Radon	3.82 day	α	5.48(100)
Polonium-218	$_{84}Po^{218}$	Radium A	3.05 min.	α	6.00(100)
Lead-214	$_{82}Pb^{214}$	Radium B	26.8 min.	β	1.03(6), 0.66(40), 0.46(50), 0.40(4)
				γ	0.35(44), 0.29(24), 0.24(11), 0.05(2)
Bismuth-214	$_{83}Bi^{214}$	Radium C	19.7 min.	β	3.18(15), 2.56(4), 1.79(8), 1.33(33), 1.03(22), 0.74(20)
				γ	2.43(2), 2.20(6), 2.12(1), 1.85(3), 1.76(19), 1.73(2), 1.51(3), 1.42(4), 1.38(7), 1.28(2), 1.24(7), 1.16(2), 1.12(20), 0.94(5), 0.81(2), 0.77(7), 0.61(45)
Polonium-214	$_{84}Po^{214}$	Radium C′	160×10^{-6} sec.	α	7.68(100)
Lead-210	$_{82}Pb^{210}$	Radium D	19.4 yr.	β	0.06(17), 0.02(83)
				γ	0.05(4)
Bismuth-210	$_{83}Bi^{210}$	Radium E	5.0 day	β	1.16(100)
Polonium-210	$_{84}Po^{210}$	Radium F	138.4 day	α	5.30(100)
Lead-206	$_{82}Pb^{206}$	Radium G	Stable		

*University of Chicago (1964).

This convention is used to differentiate common elements of the natural decay series of uranium-238, uranium-235, and thorium-232, e.g., radium-226 in the uranium-238 series in contrast to radium-224 in the thorium-232 decay series.

Each change in nuclide of a series involves the release of energy in the form of alpha, beta, or gamma radiation through a process of disintegration: alpha emissions are the release of positively charged particles (two neutrons bound to two protons) equivalent to the nucleus of a helium atom; beta emissions are the release of very high-energy electrons; and gamma emissions are the release of very high-energy electromagnetic radiation. The rate at which an unstable radioactive nuclide will disintegrate is called its "half-life," which is an expression of the time it takes for one-half of the original material to decay to the next successive daughter nuclide. For example, uranium-238 has a half-life of 4.5 x 10^9 years and a specific radioactivity of 3.33 x 10^{-7} curies per gram.* The natural uranium-238 decay series is shown in Table 4.1 with isotope name, symbol, historical name, half-life, radiation type, and emission energies in terms of millions of electron volts (MeV).

Ionizing radiation consists of directly or indirectly ionizing particles or a mixture of both. Directly ionizing particles are charged (electrons, protons, alpha particles, etc.) and have sufficient kinetic energy to produce ionization by collision. Indirectly ionizing particles are uncharged (neutrons, photons, etc); they can liberate directly ionizing particles or initiate a nuclear transformation. Alpha particles have very low penetrating power (e.g., they can be stopped effectively by a piece of paper) but have strong ionizing power and thus are dangerous to the skin or if taken internally. Beta particles are more penetrating but less ionizing. Gamma radiation is the most penetrating but has generally less ionizing capability.

The nature of the uranium-238 decay scheme is such that the daughter products are generally in secular equilibrium with the parent material at least through radium-226 (USEPA 1975b). Secular equilibrium occurs in undisturbed materials when the parent nuclide has a very much longer half-life than all succeeding daughters. In this case, the decay of the parent controls the production of daughter atoms, leading eventually to an equilibrium state in which the number of disintegrations per unit time is the same for the parent and all daughter nuclides. Under this condition, for example, radium-226 will generate an equal amount of radon-222 in terms of activity (Misaqi 1976). Habashi (1966) states that "in sedimentary phosphates, uranium exists in radioactive equilibrium with its decay products and therefore the total gamma activity of a sample may be taken as a direct measure of its uranium content;" i.e., he concurs that equilibrium exists throughout the entire uranium-238 decay series.

Total equilibrium (i.e., through the complete chain) is maintained only if the materials are totally undisturbed. Phosphate mining is a disturbance, as is the differential dissolution of materials by ground waters and the separation of materials in the production of phosphoric acid. Once the materials are disturbed, according to Saunders and Potts (1977), "as a 'rule-of-thumb', it takes about 10 half-lives for an intermediate radioelement in a decay series with a longer-lived parent to recover equilibrium and about the same time for it to essentially decay completely when separated from its longer-lived parent."

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*A curie equals 3.7 x 10^{10} disintegrations per second and is used as a measure of radioactivity of any substance.

The radionuclides of greatest importance to this program are uranium-238, radium-226, and radon-222. Uranium-238 is important because of its abundance in the area and because it is the parent material that establishes the disintegration rate under conditions of secular equilibrium for the more hazardous daughter products. Of the several uranium-238 decay products, radium-226 and radon-222 (and its principal daughter products)* are the most hazardous to human health if present in sufficient quantities; radium-226 is of particular concern because of its toxic character and its affinity for replacing calcium in bone. (Radium replacement is displayed by the relatively high radium-226 concentrations found in gypsum ($CaSO_4 \cdot 2H_2O$) stacks at the fertilizer manufacturing plants.) Radium-226 may be ingested through drinking water in which the material has been dissolved and through foods containing minute quantities of the material. Radon-222, an inert gas with a relatively short half-life (3.82 days), can be breathed along with its decay products as particulate matter associated with respirable particles of dust.

Radiation from radionuclide decay physically or structurally changes most materials through ionization and electronic excitation of the atoms or molecules of the material. The exact nature of radiation effects on man is still not understood, but cell damage is known to occur; it is also known that healthy tissue has a high recuperative power and that permanent damage to the human body can be avoided if radiation doses are low. The permissible amount of radiation that will not lead to permanent damage of the body has not been precisely determined but is known to vary from one individual to another.

As stated earlier, man's exposure to radiation can be the result of both external and internal irradiation, i.e., by being near a radiation source or by inhaling or ingesting radioactive materials. Internal irradiation can be especially harmful to vital organs of the body because of their proximity to the radioactive emitter. Damage from nuclear radiation is thought to be more severe when the body is subjected to large doses in a relatively short time than when the same exposure occurs over a longer time. Long-term effects of low radiation doses are not fully known.

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*Polonium-218, lead-214, bismuth-214, and polonium-214.

2. Radiation Measurement

Environmental radioactivity is expressed in very small units of measurement, the most common being the picocurie (pCi) or one millionth of one millionth of a curie (Ci x 10^{-12}). This convention expresses the number of radioactive disintegrations per second in a host material such as water, soil, or rock. Radium-226 concentrations in water may be given in picocuries per liter; in soils and rocks, picocuries per gram. As established, a curie is 3.7 x 10^{10} radioactive disintegrations per second; thus, a picocurie is 2.2 disintegrations per minute. Environmental measurement of host materials is by metric units (liters and grams, or milliliters and milligrams, rather than gallons or pounds).

As pointed out by the Florida Department of Health and Rehabilitative Services (FDHR&S 1974), under conditions of secular equilibrium it is the unit curie which is in equilibirum; hence, the number of atoms (or weight) of a nuclide in a decay series that is required to generate 1 curie of radioactivity varies through many orders of magnitude, depending on the decay rate of the particular nuclide.* For example, 1 gram of radium-226 will produce 1 curie of radioactivity (the definition of a curie), whereas 3 x 10^6 grams of uranium-238 is required to produce 1 curie; under standard conditions of temperature and pressure, however, only 6.6 x 10^{-6} liters of radon-222 will produce 1 curie of radioactivity (Misaqi 1976). Thus, for a given uranium content in a soil or specific zone of the phosphate deposit, the content of radium-226 (and radon-222) can be computed. Thus, the equilibrium ratio of uranium-238 to radium-226 by weight is 3 x 10^6:1. FDHR&S (1974), for comparison, states that there is on the order of 27.2 metric (30 short) tons of uranium and 10 grams (2.2×10^{-2} pounds) of radium per 259.2 hectares (1 square mile) to a depth of 1.5 meters (5 feet) in ordinary backyard soil, a uranium:radium ratio of 2.7×10^{6}:1. For this example, the radon-222 content, assuming none of the gas escapes (an unlikely condition), would be about 6.6×10^{-5} liters (0.004 cubic inches).

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*It should be noted again that equilibrium is destroyed in the acidulation process used to make phosphoric acid because of preferential dissolving of constituents; equilibrium also tends to be destroyed by natural processes such as groundwater leaching of in-situ materials.

Environmental radiation must be measured in terms of intensity (the amount of radiation passing through a unit area perpendicular to the radiation in unit time) and quantity (the time integral of the intensity). Also to be considered is the energy absorption capability of an irradiated mass; according to Liverhant (1960), the energy absorption coefficient (of an irradiated mass) depends on the absorber and varies with the energy of the radiation. Therefore, the same intensity of radiation of different energies generally will be absorbed at different rates. The common term used to describe the amount of radiation absorbed by a specific mass is the dose or dose rate. The dose is generally quantitized in terms of roentgen (R), which is defined as the X or gamma radiation which, upon passing through dry air at standard temperature and pressure, liberates a number of secondary particles in 1 cubic centimeter of air, which will produce air ions carrying 1 electrostatic unit (esu) of electricity of either sign. Thus, dose rate is the energy absorption equivalent to 1 roentgen per second. The energy transfer in air corresponding to 1 roentgen can be determined by considering that a singularly charged ion carries a charge of 4.8×10^{-10}, thus establishing 2.08×10^{9} ion pairs per electrostatic unit. The energy required to create an ion pair in air is 35 electron volts (ev), and 1 ev = 1.6×10^{-12} ergs (energy equivalents). Conversion leads to the energy transfer relationship of 90 ergs per gram of air per r[illegible]gen of radiation. The energy transfer per roentgen in materials other than air depends on the absorption properties of the material; for biological tissue, which consists mainly of water, the energy transfer per roentgen is taken as 100 ergs per gram, which is called a rad, an international unit of absorbed dose. A rad also is equivalent to 6.25×10^{7} Mev per gram.

Radiation damage is determined by not only the total amount of ionization in tissue but the specific ionization character of the incident radiation. According to Liverhant (1960), "for equal doses, the more heavily ionizing radiation like alpha particles are more damaging than beta particles and gamma radiation which cause a more diffuse ionization." This leads to the term "relative biological effectiveness" (rbe), which is defined with reference to a particular type of damage as:

$$\text{rbe} = \frac{\text{absorbed dose (erg per gram of X radiation}}{\text{absorbed dose (erg per gram) of radiation considered}}$$

In its 1959 report, the International Commission on Radiation Units and Measurements (ICRU 1968) expressed misgivings over the use of rbe in both radiobiology and radiation protection and recommended that the term be used only in radiobiology:

> "In radiation protection it is necessary to provide a factor that denotes the modification of the effectiveness of a given absorbed dose by LET (linear energy transfer). Unlike rbe, which is always experimentally determined, this factor must be assigned on the basis of a number of considerations, and it is recommended that it be termed the quality factor (QF). Provisions for other factors are also made. Thus, a distribution factor (DF) may be used to express the modification of biological effect due to nonuniform distribution of internally deposited radionuclides. The product of absorbed dose and modifying factors is termed the dose equivalent (DE). As a result of discussions between the ICRU and the ICRP [International Commission on Radiological Protection and Measurements], the following formulation has been agreed upon:
>
> "• For protection purposes, it is useful to define a quantity which will be termed "dose equivalent" (DE).
>
> "• DE is defined as the product of absorbed dose (D), quality factor (QF), absorbed dose distribution factor (DF), and other necessary modifying factors:
>
> $$DE = D\ (QF)\ (DF)\ \ldots\ldots\ldots$$
>
> "• The unit of dose equivalent is the rem. The dose equivalent is numerically equal to the absorbed dose in rads multiplied by the appropriate modifying factors.
>
> "Although this statement does not cover a number of theoretical aspects (in part the physical dimensions of some of the quantities), it fulfills the immediate requirement for an unequivocal specification of a scale that may be used for numerical expression in radiation protection."

Another common term is the man-rem (or person-rem) used in dealing with a given population's total exposure to radioactive material (for example, in drinking water). Assuming that a population of 10,000 occupies an area in which it is subjected to 0.2 millirem per year because of uptake of radium-226 in drinking water and considering that the conversion factor relating annual comsumption of water to radiation dose of 1 picocurie per liter is 6 millirem per year (USEPA 1974b), the man-rem for bone surfaces would be 2.0 (0.2 millirem per year x 10,000).

The term used to express radiation levels in air for radon-222 daughter product activity is the working level (WL), defined as any combination of short-lived radon daughter products in 1 liter of air that will result in the ultimate emission of 1.3 x 10^5 Mevs of alpha energy. An equivalent numerical value is 100 picocuries per liter of radon-222 in equilibrium with its short-lived daughter products in air (Paterson 1970). A working level month (WLM) is the term used to express the occupational exposure in a working month (170 hours), e.g., by a uranium miner laboring in an atmosphere containing radon daughter products; i.e., a working month in an atmosphere containing 1 WL of radon daughter products equals 1 WLM. Cumulative working level months (CWLMs) express the total accumulated occupational exposure to radon daughter products over a cumulative period; e.g., 1 year of exposure at a rate of 1 WLM per month equals 12 CWLMs. Since occupational exposures are based on 170 hours per month and continuous exposure involves approximately 170 hours per week, continuous exposure to an air concentration of 1 WL is equivalent to occupational exposure of 4.2 WLs (4.2 weeks per month).

Other terms pertaining to radiation dose include:

- Absorbed dose: the quantity of energy imparted to a mass of material exposed to radiation
- Cumulative dose (radiation): the total dose resulting from repeated exposures to radiation of the same region or of the whole body
- Permissible dose: the amount of radiation that may be received by an individual within a specified period with expectation of no significantly harmful result

- Maximum permissible dose: maximum dose of radiation that may be received by persons working with ionizing radiation

Another term often used is:

- Maximum permissible concentration (MPC): the amount of radioactive material in air or water that may be expected to result in a maximum permissible dose to persons consuming them at a standard rate of intake

The complexity of measuring radiation and deducing the effects of radiation on exposed organisms is obvious in the foregoing discussion. To offer an understanding of the overall problem of radiation level/impact assessment for the study area, the following paragraphs discuss radiation measurements by various researchers within the context of radiation exposure guidelines established by the various international, national, state, and local agencies and groups charged with maintaining the quality of the environment. Health effects are discussed only when specific exposure times, coupled with range-to-source estimates, can be established for inhabitants of the area or for industry workers.

3. Radiation Guidelines and Standards

Guidelines for radiation doses generally are given in terms of dose rate above existing natural background levels, but all radiation exposure is considered harmful and adverse effects are assumed proportional to dose; in other words, a linear nonthreshold theory rather than a threshold hypothesis is accepted.

Numerous guidelines, recommendations, and standards for protection against radiation have been published by the Atomic Energy Commission (AEC), the U.S. surgeon general, the U.S. Bureau of Mines (USBM), the Occupational Health and Safety Administration (OSHA), and various committees such as the National Council on Radiation Protection and Measurements (NCRP), International Commission on Radiological Protection (ICRP), and Federal Radiation Council (FRC) (USEPA 1974a). The following summarizes the recommendations of these various groups.

a. Ambient Radiation (Background and Air)

The surgeon general's office (Peterson 1970), in commenting on dwellings constructed with or on uranium mill tailings, states that "no action is indicated when the external gamma exposure rate is less than 0.05 mR/hr (50 mR/hr) and the radon daughter product activity is less than 0.01 WL since, under conditions of continuous exposure, these levels would result in maximum annual exposures of approximately 400 mrem and 0.5 CWLM, respectively. The maximum annual value of 400 mrem is less than the dose limits recommended for an individual member of the general public by the FRC and ICRP for whole body exposure to gamma radiation" [which is 500 mrem (Florida Department of Health and Rehabilitative Services 1977)]. Further, according to the surgeon general (Peterson 1970), "remedial action may be suggested in the case of external gamma exposure rates of 0.05-0.10 mR/hr (50-100 mR/hr) or radon daughter product activities of 0.01-0.05 WL since, under conditions of continuous exposure, these levels would result in maximum annual exposures of approximately 400-900 mrem and 0.5-2.5 CWLMs. The upper limit of these ranges exceeds the strictly applied recommendations of the FRC and ICRP for exposures of an individual member of the public... Remedial action is indicated at gamma exposures greater than 0.1 mR/hr (100 mR/hr) at radon daughter product activities greater than 0.05 WL. Under conditions of continuous exposure, these levels would result in minimum annual exposures of 900 mrem and 2.5 CWLMs."

In 1966, the ICRP recommended that the annual dose limit for members of the public be one-tenth of the corresponding annual occupational maximum permissible dose, stating that the recommended maximum annual value of 0.5 CWLM of radon daughter product exposure is approximately one-tenth the 4 CWLM annual occupational exposure limit recommended by the FRC (Federal Register 1969) and less than one-twentieth the annual occupational exposure limit of 12 CWLMs of radon daughter product exposure recommended for uranium miners in FRC regulations (Peterson 1970).

The Occupational Safety and Health Standards of the Department of Labor, as published in the Federal Register, Vol. 37, No. 202, Section 1910.96, October 1972, states that no individual in a "restricted area" should receive a radiation dose equivalent to 5 rem (5000 mrem) per year to the whole body or 15 rem (15,000 mrem) per year to the lung (Windham et al 1976). (A restricted area is defined as an area of controlled access to protect against radiation.)

Maximum recommended doses for persons in nonrestricted areas (general population) were given as 0.5 rem (500 mrem) per year to the whole body and 1.5 rem (1500 mrem) per year to the lung, or 10 percent of the occupational dose.

The NCRP, in its report No. 39 (NCRP 1971), discusses average population dose limits in terms of genetic and somatic (whole body/critical organ) considerations relative to man-made radiation, stating that "the dose equivalent to the gonads for the population of the United States as a whole from all sources of radiation other than natural radiation and radiation from the healing arts shall not exceed a yearly average of 0.17 rem (170 mrem) per person" and that "the dose equivalent to the critical organs (whole body) for the population of the United States as a whole from all sources of radiation other than natural radiation and radiation from the healing arts shall not exceed a yearly average of 0.17 rem (170 mrem) per person." This deals with the U.S. population in total and expresses limits on an average basis. The report also discusses an individual member of the population relative to man-made radiation, stating that "the dose limit for the critical organs (whole body) of an individual not occupationally exposed shall be 0.5 rem in any one year, in addition to natural radiation and medical and dental exposures."

Currently, there are no federal, state, or local radiation protection guidelines specific to radionuclide concentrations in the soil that might lead to increased gamma radiation exposure at the surface or increased radon daughter product exposure in structures in natural background areas or on reclaimed phosphate-mined land. The EPA, in addressing the potential for increased exposure because of uranium in the Bone Valley formation underlying a large portion of the 7-county study area and its redistribution by the phosphate industry during reclamation, published its preliminary recommendations for radiation exposure levels in structures constructed on Florida phosphate lands. In its draft document (USEPA 1977) which considered data developed for reclaimed mined land, debris land,* and background land, exposure levels were categorized as follows according to remedial action recommendations:

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*Debris land is previously mined land containing potentially recoverable phosphate; it is not necessarily reclaimed land.

Indoor Radon Daughter Product Exposure Level (WL)*	External Gamma Radiation Exposure Level (μR/hr)*	Recommendation
< 0.005	< 3	No action indicated
0.005-0.02	3-60	Remedial action may be warranted
> 0.02	> 60	Remedial action indicated

*Preliminary net values (background not included) not yet subjected to public hearing as required by law.

The USEPA (1974a) states that:

> "In the case of air quality, both the Bureau of Mines and the Occupational Safety and Health Administration have standards relative to radiation. Both arise, however, in recognition of the occupational hazard resulting from radon in uranium mining operations. The Bureau of Mines regulations (30 CRF 57) prohibit exposure to airborne contaminants exceeding the threshold limit values in the publication Threshold Limit Values of Airborne Contaminants. This document, however, incorporates NBS Handbook 69 for permissible concentrations of radioisotopes in air. Exposure to radon daughters is further limited in terms of working level months (WLMs)... The regulations prohibit an exposure of more than 6 WLMs in any consecutive 3-month period and more than 12 WLMs in any consecutive 12-month period. In addition, with atmospheric concentrations between 1.1 and 2.0 WLs, immediate corrective action must be taken and, when above 2.0, workers must be withdrawn until such action is taken. The Occupational Safety and Health Administration, on the other hand, limits occupational exposure in mines to no more than 2 WLMs in any calendar quarter and no more than 4 WLMs in any calendar year. Applicability of either set of standards to other than mining operations would be questionable."

b. Water

In August 1975, the Environmental Protection Agency proposed national interim primary drinking-water regulations for radioactivity (USEPA 1975c). On July 9, 1976, regulations for radioactivity in drinking water were promulgated in final form, as summarized in the following:

- Maximum contaminant levels for radium-226, radium-228, and gross alpha particle radioactivity in community water systems
    - Combined radium-226 and radium-228 shall not exceed 5 picocuries per liter.
    - Gross alpha particle activity (including radium-226 but excluding radon and uranium) shall not exceed 15 picocuries per liter
- Maximum contaminant levels for beta particle and photon radioactivity from man-made radionuclides in community water systems
    - The average annual concentration in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem per year.
    - Except for the radionuclides tritium and strontium-90, the concentration of man-made radionuclides causing 4 millirem per year total body or organ dose equivalents shall be calculated on the basis of a 2-liter-per-day drinking-water intake using the 168-hour data listed in Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure (NBS Handbook 69) (USEPA 1975c). If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any organ shall not exceed 4 millirem per year.

Handbook 69 provides a series of recommended levels of about 200 radioisotopes for *occupational* exposure: for continuous exposure of the critical organ (in this case, bone) to radium-226, the maximum permissible concentration (MPC) in water is 100 picocuries per liter; for continuous occupational exposure of persons outside the controlled area, this is reduced to 10 picocuries per liter. The controlled-area value is based on 168 hours of occupational exposure per month (Federal Register 1976c).

Most considerations of aggregate dose levels for populations involve both the risk to individuals and the total risk to the population served, so the maximum contaminant level would be inversely related (within limits) to the size of the exposed population. Because of this, as noted in the preamble to the proposed radionuclides regulations (40 FR 34325), the EPA considered but rejected the use of an aggregate dose level in establishing maximum contaminant levels (Federal Register 1976c).

The EPA (1974a) states that the FRC has defined ranges for total daily radium-226 intake and recommended countermeasures as follows:

Picocuries	Countermeasure
0-2	Periodic confirmatory surveillance
2-20	Quantitative surveillance and routine control
20-200	Evaluation and application of additional control

The ERDA guideline for release of radium-226 to an environment (including residential quarters) for which control is not maintained for purpose of protecting individuals from exposure to radiation is 30 picocuries per liter (USEPA 1974a). For radon-222 in water, there are at present "no accepted standards" (USEPA 1974a). However, Maine's Department of Health and Welfare has established a tentative state guideline for permissible concentration of radon-222 in water to be:

Occupational dose, 180,000 picocuries per liter

For an individual in a population, 18,000 picocuries per liter

For public water supplies, 16,000 picocuries per liter

According to Guimond and Windham (1975), "under the provisions of the Federal Water Pollution Control Act of 1972, as amended, the Environmental Protection Agency is required to establish effluent limitation guidelines for fertilizer and phosphate manufacturing and to issue National Pollutant Discharge Elimination System (NPDES) permits for individual fertilizer and manufacturing facilities. Because of the need to expeditiously issue permits to such facilities, interim guidelines for permits recommended an effluent limitation of 9 pCi per liter total radium-226 pending results from additional studies."

4. Radiation Background in Study Area

The radiation background of the study area is defined as those radiation levels existing outside the influence of the phosphate industry. Unfortunately, this may be an ambiguous definition because there is no precise definition of what constitutes influences by the industry. Background radiation refers to that from natural sources (e.g., the sun, soil, and even the phosphate deposit) and from air, food, and drinking water not impacted by industry activities.

An inescapable part of the overall background radiation at the earth's surface is cosmic radiation. Cosmic rays, extremely high-energy radiation intercepted by the earth, consist chiefly of high-speed protons; energies as high as 10^{17} electron volts have been observed in cosmic-ray particles (Uvarov and Chapman 1971). Herbst (1964) showed a dependence of cosmic-ray exposure on height above sea level (Figure 4.1): for sea level, 3.2 microroentgens per hour, which corresponds to 28 milliroentgens per year; for 3000 meters (9840 feet), 14 microroentgens per hour and 120 milliroentgens per year (1.0 microroentgens per hour = 8.76 milliroentgens per year). According to Herbst (1964), the mean gamma dose rate from the earth's crust in air is 76.1 milliroentgens per year and the mean dose rate from cosmic radiation is 38.4 milliroentgens per year; thus, the mean natural background dose rate to which individuals are exposed is about 114 milliroentgens per year. These values, compounded by habits of living (undefined but assumed to include variable types of housing structures), are corrected to 31 milliroentgens per year for cosmic radiation and 91 milliroentgens per year from the terrestrial environment (Herbst 1964).

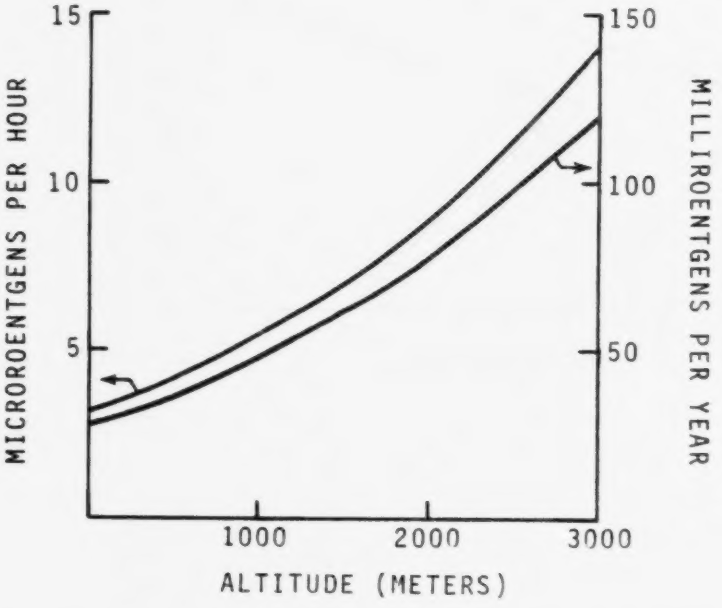


Figure 4.1. Cosmic Radiation Intensity as Function of Altitude (Herbst 1964)

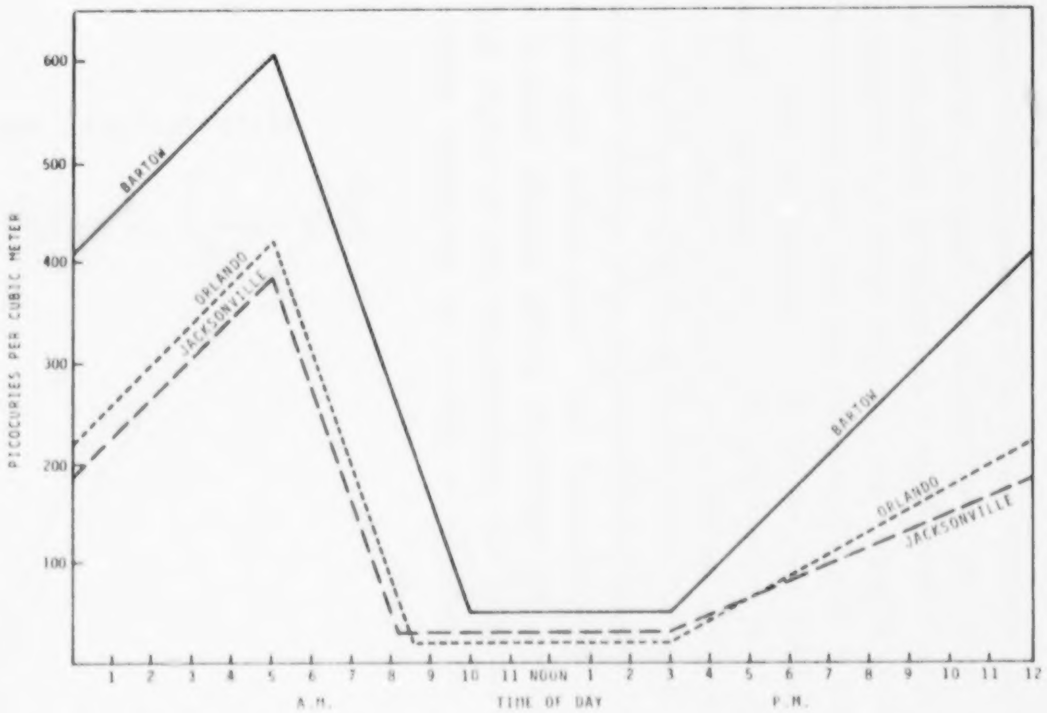


Figure 4.2. Average Radon-222 Diurnal Variation in Bartow, Orlando, and Jacksonville, March 1964-February 1965 (Williams et al 1965)

The average gamma radiation measured at Mulberry, Florida, has been cited by Gallagher and Palm (1975) to be 115 milliroentgens per year. CF Mining Corporation (1976) points out that "external gamma radiation levels in Polk County in the vicinity of phosphate beds have been measured and found to be on the order of 60 to 115 mR/yr; these measurements take into account cosmic radiation as well as gamma sources in the underlying soils. Florida readings agree well with the approximately 105 mR/yr gamma level average for the U.S., of which about 45 mR/yr is attributable to cosmic radiation and the remainder to terrestrial sources."

Terrestrial gamma radiation's source is all things in the environment, including soil, building and road materials, and air. As an example, radon-222 gas escapes from the soil and, through its process of decay, produces gamma radiation that contributes to the terrestrial gamma radiation background. Radon flux into the atmosphere is highly variable and is affected by air temperature, barometric pressure, precipitation, and wind; it tends to accumulate in topographic depressions in the early morning hours. Kraner et al (1964) discusses these effects at length. The chain from radon-222 to bismuth-214 (the principal gamma emitter) consists of short half-life members and is controlled by the radon-222 decay rate unless rainfall washes the radon daughters out of the atmosphere. Such events can cause surface gamma radiation from bismuth-214 to rapidly reach levels several times normal and to subsequently decay at a rate controlled by the half-lives of lead-214 (26.8 minutes) and bismuth-214 (19.7 minutes). (The remainder of the decay chain to lead-206 is of no consequence to field gamma measurements [Saunders and Potts 1977] and thus is of little significance to the study.)

In a study of radon-222 concentrations in air in Bartow, Orlando, and Jacksonville, Williams et al (1965) found that the lung dose from daughter products for individuals residing in Bartow was 50 percent higher than in Orlando and 100 percent higher than in Jacksonville as measured near the St. Johns River; they concluded that 75 to 90 percent of the total dose resulted from inhalation of airborne radioactivity occurring during the 15-hour period from 5 pm to 8 am, as shown in Figure 4.2. The average of the 8 am and 3 pm concentrations for the three cities were: Bartow, 160 picocuries per cubic meter; Orlando, 55 picocuries per cubic meter; and Jacksonville, 40 picocuries per cubic meter. The lung doses for these values depend of whether an individual is working vigorously or lightly or is resting and the percentage of the day in which each activity occurs. Comparing the results of two lung dose evaluations for the concentrations, Williams et al (1965) showed that 9 hours per day of light work plus rest resulted in approximately one-half the lung dose that 9 hours per day of vigorous work plus rest would produce. Respective daily lung doses for the measured "concentrations" appear in Table 4.2.

Table 4.2. Estimated Lung Doses from Atmospheric Concentrations of Radon-222 Daughters*

City	Average (8 am-3 pm) Radon-222 Concentration (pCi/m^3)	Light Work + Rest		Vigorous Work + Rest	
		Eval 1 (rad/yr)	Eval 2 (rad/yr)	Eval 1 (rad/yr)	Eval 2 (rad/yr)
Orlando	55	0.048	0.044	0.083	0.075
Jacksonville	40	0.035	0.032	0.060	0.055
Bartow	160	0.140	0.128	0.240	0.219

*Williams et al (1965)

The mean content of radium-226 in Florida soils is 1.5 picocuries per gram with a calculated resultant gamma dose in air of 2.7 microroentgens per hour and 24 millirem per year (Florida Department of Health and Rehabilitative Services 1975). EPA (1975b) states that in areas in which there is no phosphate-related material the total gamma radiation background from all sources is generally quite low - approximately 5 to 7 microroentgens per hour.

Also included in total exposure of the study area's population are radioactive materials inhaled and ingested. Because of the myriad of variables (radioactivity in the near-surface atmosphere results from the interaction of a variety of factors including source-material positioning, time of day, season, weather, and airmass movements), air concentrations of the naturally occurring radioisotopes that are being produced at a constant rate in the earth's crust vary so greatly that, even when averaged over relatively long periods, defining the natural radioactivity background at a given site becomes impossible by any but an extended series of measurements (Lockhart 1964). Such extensive measurements of the atmosphere in the 7-county area have not yet been made. Also to be considered as part of the background exposure to gamma radiation is that received through application of medical technology, e.g., X-ray exposure in dental and medical diagnosis — approximately 70-100 milliroentgens per year (Gallagher and Palm 1975). Thus, gamma radiation exposure of the population in the 7-county study area to cosmic radiation, terrestrial radiation outside the immediate phosphate area, and medical sources would be approximately 200-300 millirem per year. Exposures of individuals within the area of the phosphate industry would depend on specifics: locations relative to mined areas, reclaimed lands, ore storage piles, and chemical process plants, as well as other disturbed-earth and cultural locations associated with the industry. These are discussed in subsection C.

The ingestion of foods containing radioactive material is considered a minor pathway relative to the others mentioned. According to Guimond (1977), present knowledge makes it extremely difficult to quantify precisely the national impact of the uptake of radionuclides in the food supply:

> "The uptake has been shown to be dependent upon several factors including solubility, crop type, soil type, and calcium concentration in the soil. In most cases, the relative concentration factor was less than 0.1, suggesting that the radionuclides are excluded to various degrees."

Eisenbud et al (1964) report average intake of radium-226 in food for several U.S. locations to range from 1.7 to 2.3 picocuries per day.

Particularly important to man's overall background exposure in the study area is the ingestion of radionuclides in drinking water. Kaufmann and Bliss (1977) reviewed the most recent data on radionuclides contained in water supplies as compiled by Irwin and Hutchinson (1976) for 105 drilled wells, 80 private wells, and 25 municipal wells scattered throughout the study area. The observed ranges of radon-222 and radium-226 concentrations appear in Table 4.3. Individual wells were not labeled as to usage, but the 80 private wells served 1350 persons and the 25 municipal wells served 157,300 persons. Specific values for radionuclides in municipal samples are presented in Table 4.4.

Table 4.3. Radon-222 and Radium-226 Concentrations in Central Florida Ground Waters*

Samples	Picocuries per Liter Radon	 Radium
105 Drilled Wells		
90%	<8430	<4.6
75%	<4160	<2.4
50%	<1860	<1.2
25%	< 260	<0.5
Range	23-46,600	0.0-76
80 Private Wells		
90%	<9460	<4.6
75%	<4190	<3.9
50%	<2780	<1.4
25%	< 970	<0.5
Range	23-46,600	0.0-76
25 Muncipal Wells		
Range	35-720	0.0-4.1

*Irwin and Hutchinson (1976).

Irwin and Hutchinson also sampled several surface-water locations during their study, and the data for four of their samples are presented in Table 4.5. Also, Kaufmann and Bliss (1977) summarized the USGS 1976 and the EPA 1973-76 data sets for background radium-226 concentrations in ground waters of the study area (Table 4.6).

Table 4.4. Radionuclide Concentrations in Municipal Well Supplies, Central Florida*

Municipal Supply	Depth of Well (ft)	Picocuries per Liter** Rn-222	Ra-226	U	Th	Pb-210	Po-210	Cross Alpha	Cross Beta
Bartow Well 3	650	260	1.6	-	-	-	-		
Bartow (treated) - aeration, filtration, chlorination		80	1.4	-	-	-	-		
Winter Haven wells									
1	593	20	0.67	-	-	-	-		
2	816								
Winter Haven wells									
3	648	95	0.58	1.2	0.12	0.0	0.0	2.7	2.7
4	640	-	-	-	-	-	-	-	-
Lake Wales Well 1, Market St. plant (raw)	1022	60	0.76	-	-	0.2	0.1	3.3	8.2
Lake Wales Well 1, Grove Ave. plant (raw)	1063	35	0.47	-	-	-	-		
Avon Park (raw)		560	0.98	0.7	0.11	0.5	0.1	3.7	3.7
Sebring, Franklin St well (raw)	1480	140	-	0.7	0.11	0.2	0.1	0.4	3.8
Arcadia Well 1 (raw)	495	480	3.3	0.9	0.52	0.6	0.1	4.9	24
Arcadia (treated) - aeration, chlorination		210	2.5	-	-	-	-		
Bowling Green at water tank		260	2.7	0.9	0.15	0.3	0.3	2.4	11
Plant City Well 3	750	150	0.77	-	-	-	-		
Plant City Well 2	368	360	0.00	1.2	0.06	0.1	0.0		
Zephyrhills	425	360	0.31	1.2	0.00	0.3	0.0	2.9	-
Dade City Well 1	150	[illegible]	[illegible]	-	-	-	-		
Clermont South well	525	600	0.39	-	-	-	-		
Clermont Highland well	550	720	0.29	1.8	0.04	0.1	0.0	0.8	
Lake Alfred Well 4 (raw)	560	220	4.1	-	-	-	-		
Lake Alfred (treated) - aeration, chlorination		50	1.8	-	-	-	-		
Dundee well, City Park		560	0.0	-	-	0.0	0.0	0.7	4.2
Haines City Well 7	800	125	0.74	-	-	-	-		
Haines City Well 8	565	115	0.73	-	-	-	-		
Auburndale, Tampa St. well	616	110	0.50	-	-	-	-		
Auburndale, water plant well		85	0.53	-	-	-	-		
Lakeland well, 9 N. Florida Ave.	865	160	0.80	-	-	0.1	0.1		
Lakeland Well 22	891	260	0.84	-	-	-	-		
Mulberry Well 1	778	165	0.45	1.4	0.06	0.4	0.1		
Medula Recreation Center north of Mulberry		320	0.23	-	-	-	-		

*Irwin and Hutchinson (1976)

**Except uranium (U), which is expressed in micrograms per liter.

Table 4.5. Concentration of Radon-222 and Radium-226 in Surface Waters of Central Florida*

Sample Location	Picocuries per Liter	
	Radon-222	Radium-226
Lithia Springs-Thermal Springs	2360	0.65
Alafia River-SR 640 at bridge (state sampling point A4)	45	0.21
Natural well-Hwy 640 at bridge over south fork of Alafia River	300	2.05
Peace River at Saddle Creek	20	0.65

Table 4.6. Radium-226 in Ground Water in Unmined Mineralized and Unmineralized Regions of Central Florida*

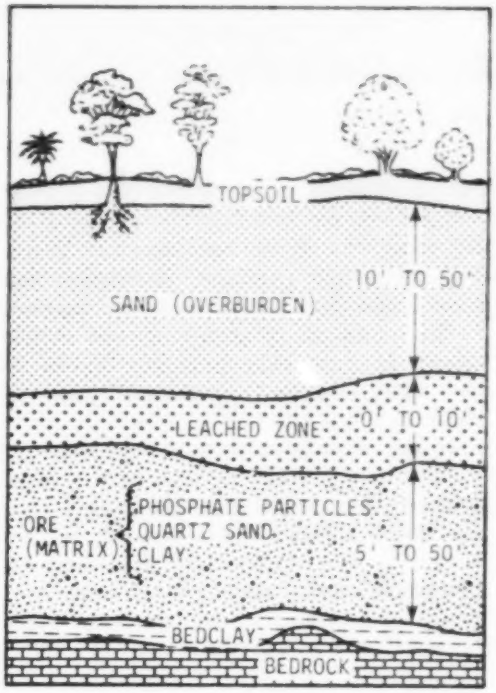
Region	Aquifier		Picocuries per Liter			
			EPA		USGS	
Minearlized, Unmined	Water Table	No.	3		23	
		Mean	1.63		0.17	**
		SD	1.56		12.9	
		Range	0.20-3.30		0.05-22.0	
	Upper Floridan	No.	9		5	
		Mean	3.06		2.30	**
		SD	3.35		3.35	
		Range	0.18-10.6		0.24-7.7	
	Lower Floridan	No.	24		9	
		Mean	2.0	**	1.4	
		SD	2.3		1.3	
		Range	0.19-15.3		0.06-4.7	
Nonmineralized	Water Table	No.	No data		No data	
		Mean				
		SD				
		Range				
	Upper Floridan	No.	No data		3.0	
		Mean			5.1	**
		SD			4.3	
		Range			0.2-7.9	
	Lower Floridan	No.	14		2.0	
		Mean	1.4	**	2.8	
		SD	2.5		1.4	
		Range	0.23-14.7		1.8-3.8	

*Kaufmann and Bliss (1977)

**Data set used in analysis by Kaufmann and Bliss.

B. URANIUM OCCURRENCES IN PHOSPHATE ORES AND SURROUNDING MATERIALS

Uranium is the parent material of virtually all the daughter radionuclides that may impact the health of the population of the study area. Section 3 of this volume identified various near-surface materials associated with the phosphate ore body and discussed the concentration of uranium in each. These identifications and concentrations are summarized in Figure 4.3; the identification of geologic units are those of Fountain and Zellars (1972), and the concentrations of uranium as U_3O_8 have been taken from Altschuler et al (1955), Cathcart (1955), and McKelvey (1955). For comparison, Table 4.7 displays the natural uranium and thorium content of common geologic materials in the region.



U_3O_8 Equivalents	U_3O_8 Equivalents
<0.0005%	< 5 ppm* (3.3 pCi/g)
0.002 to 0.003%	20 to 30 ppm (13.4-20.1 pCi/g)
0.01 to 0.03%	100 to 300 ppm(66.9-200.1 pCi/g)
0.01 to 0.02% (High BPL) (Low BPL)	100 to 200 ppm(66.9-133.8 pCi/g (High BPL) (Low BPL)
0.002 to 0.015%	20 to 150 ppm (13.4-100.4 pCi/g)
0.001%	< 10 ppm (6.7 pCi/g)

*ppm = parts per million

Figure 4.3. Average Uranium Concentrations as U_3O_8 (Altschuler et al 1955, Cathcart 1955, McKelvey 1955) in Typical Central Florida Phosphate District Profile (Fountain and Zellars 1972)

Table 4.7. Average Uranium and Thorium Calculations for Florida Rocks*

Rock Type	Average Uranium (ppm)	Average Thorium (ppm)	Relative Rock Abundance
Limestone	2	1.5	0.3
Coral	10	0.5	0.04
Dolomite	3.5	6	0.08
Attapulgite	5	15	0.04
Montmorillonite	6	19	0.06
Kaolinite	2.5	12	0.04
Phosphorite	250	12	0.02
Sand	1.2	3	0.4
"Black" sand	50	300	0.02

*Osmond (1964)

Cathcart (1955) summarized the occurrence of uranium in the Bone Valley formation of central Florida as follows:

> "The analysis of many thousands of samples has shown that the coarser phosphate particles are higher in uranium and lower in P_2O_5 content than the finer material. Uranium content of the coarser material (pebble) averages between 0.010 and 0.020 percent, and the P_2O_5 content averages about 31.5 percent. The uranium content of the finer materials (concentrates) is commonly between 0.005 and 0.015 percent, and the P_2O_5 content averages about 34 percent. A direct relation between P_2O_5 content and uranium content is present within a size fraction, however: in pebble samples of the same size, the uranium content tends to increase as the P_2O_5 increases. The uranium content of the quartz sand fraction of the matrix is less than 0.001 percent, and the slime fraction of the matrix usually contains small amounts of uranium, averaging less than 0.005 percent, although some samples very high in P_2O_5 content have a higher uranium content."

C. INDUSTRY REDISTRIBUTION OF RADIONUCLIDES

Phosphate industry activities in the study area that lead to the extraction, processing, and marketing of phosphate materials are described in Volume I of this series. Phosphate ore extraction, its chemical separation and processing into commercial products, and the latter's subsequent wide distribution create situations in which individuals and populations are exposed to radionuclides exceeding amounts that would be encountered if the phosphate industry did not exist. This is because uranium is indigenous to phosphate and spontaneously degenerates into daughter materials with different chemical and mobility properties.

To determine the impact of industry activities relative to radiation exposures, radionuclide concentrations must be determined at the myriad of points in the mining/processing/marketing chain. Not only is the EPA currently doing this, but industry as well. Despite the amount of data already collected and analyzed, much remains to be accomplished relative to the precise understanding of radiological impacts within the study area. For example, according to Kaufmann and Bliss (1977):

> "Scientific studies constituting the radium data base now available contain major defects. Time series data have not been collected, analytical procedures have been inconsistent, mining areas and certain aquifers therein have been essentially ignored in some cases, emphasis has been on sampling water supply wells versus wells designed specifically for monitoring."

The above notwithstanding, existing data give a reasonable overview of the contrast between points of concentration of radionuclides relative to specific activities and the general background radiation levels discussed earlier.

1. Mining and Beneficiation

Industry activities, from initial prospecting through land clearing, have little effect on the redistribution of radionuclides in the environment, although it could be argued that land clearing promotes increased erosion, which leads to increased sedimentation (including radionuclides) in surface streams, and that core drilling during prospecting brings radionuclides to the surface. However, land users other than the phosphate industry would engage in similar activities that would yield the same results; for example, land designated for agriculture or urban development would be cleared and wells drilled for water and/or foundation tests. Of course, these are uses of the land that would not disrupt the geologic section to such an extent as does mining.

Mining and beneficiation do nothing to disturb the equilibrium of radionuclides in the mined materials; thus, a balance exists between uranium-238, radium-226, and the other daughter products (Guimond 1977). As shown in Figure 4.4, piled overburden, exposed bedclay, slimes, sand tailings, and marketable phosphate rock are the "products" of mining and beneficiation. According to Kaufmann and Bliss (1977):

> "The amount of radioactivity in the overburden* varies with local conditions and may primarily depend on whether a leach zone is present. [Although highly variable in extent, the leach zone is thickest in the northeast sector of the Bone Valley formation and tends to thin and disappear toward the southwest, conforming strikingly to the topography of the river valleys (Altschuler et al 1955)]. In general, uranium concentrations in the leach zone are approximately equal to those in the ore (matrix), both of which contain about 40 pCi/g of radium-226. However, overburden not containing a leach zone contains much less radium, probably on the order of 10 pCi/g or less."

Development of new surfaces by mining, i.e., exposing bedclay rather than top soil to the atmosphere, can theorectically cause a 4 to 30 times increase in uranium-238 "surface" concentration. (Compare top soil and bedclay uranium concentrations in Figure 4.3).

Sand tailings resulting from beneficiation are relatively low in radionuclide concentration and are comparable to the overburden without a leach zone — 5.3 and 10 picocuries per gram uranium-238 respectively. Neither differ markedly from soil concentrations. Again refer to Figure 4.4 for uranium (and radium) concentrations in marketable phosphate rock from a typical mining and beneficiation operation; such concentrations are relatively uniform but will vary slightly depending on the BPL (bone phosphate of lime) content of the marketed rock.

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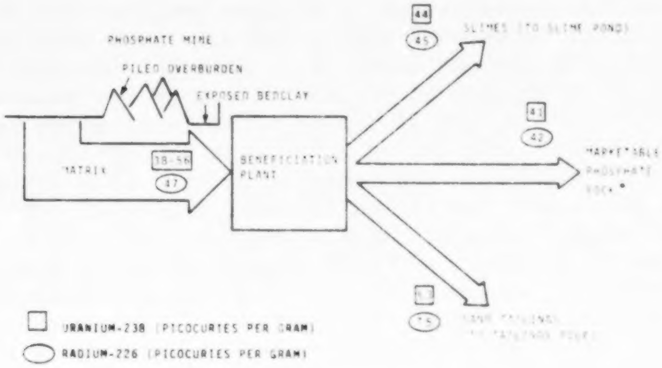
*Overburden, as used here, includes the leach (aluminum phosphate) zone where present.


PHOSPHATE MINE
PILED OVERBURDEN
EXPOSED BEDCLAY
MATRIX
38-56
47
BENEFICIATION PLANT
44
45
SLIMES (TO SLIME POND)
41
42
MARKETABLE PHOSPHATE ROCK*
15
SAND TAILINGS (TO TAILINGS PILE)
URANIUM-238 (PICOCURIES PER GRAM)
RADIUM-226 (PICOCURIES PER GRAM)

*Florida Department of Health and Rehabilitative Services (1976)

Figure 4.4. Uranium-238 and Radium-226 Concentrations in Typical Florida Phosphate Mining and Beneficiation Operation (Guimond 1976a)

Mills et al (1977) point out that:

> "In beneficiation, water is used for processing in addition to being used as a transportation medium. Several Florida slime ponds have discharges to the environment. ...Most of the radioactivity in the beneficiation wastes is present in the slimes... The concentration of dissolved radium-226 in slime discharges was less than 5 pCi/l at all facilities. The undissolved radium-226 concentration ranged from 10 to 2000 pCi/l and was highly dependent on the total suspended solids in the slimes. Although no chemical processes are used to treat the discharge from the slime ponds, concentrations of radium-226 in effluents were all less than 3 pCi/l. The reduction of total radium-226 from the raw slime discharge (from the beneficiation plant) to the effluent discharge (from the slime settling pond) ranged from 92 percent to greater than 99.9 percent. This was primarily due to the removal of suspended solids by settling."

From the foregoing, it is obvious that the release of slime-pond decant water will have little radiation impact on the environment. In the past, pond dikes have broken, releasing to the environment not only decant water but water having high solids content and corresponding high radium-226 concentrations.

The Florida State Department of Health and Rehabilitative Services (1975) calculated the radiological health consequences of a hypotehtical slime-pond dike failure using Beker Phosphate Corporation DRI (proposed Manatee County operation) as a model, with the slime discharge reaching the Manatee Reservoir:

> "To assess accidental consequences, a macimum hypothetical accident may be calculated. If it is assumed that a 350-acre [142-hectare] slime retention pond with an average depth of 20 feet [6.1 meters] (contains 8.64 x 10^7 liters) is emptied in its entirety into the Manatee Reservoir containing 3.785 x 10^{10} liters of stored water, a dilution factor of 2.28 x 10^{-3} will result. Utilizing a value of 520 pCi/liter for slimes (10 grams of solids per liter) concentrations of 1.18 pCi/liter would result. The higher level for slimes reported (2248 pCi/l-67 grams solids per liter) would result in a concentration of 5.1 pCi/liter. Both of these values are below the Federal Radiation Council Range II limit of 20 pCi/day (assuming 2 liters/day consumption) total intake of radium-226 from all sources based on data available relating to daily intake of radium-226 in foods in Florida. The conversion factor relating annual consumption of water to radiation dose is 1 pCi/l = 6 mrem/year (bone surfaces). Doses resulting from the hypothetical accident would be, therefore, if the water were consumed for one year at that concentration: 7.08-30.6 mrem/year. This compares with Radiation Protection Guide levels of 500 mrem/year to an organ for a suitable average of a population.
>
> "The foregoing calculated accident is not, however, credible. The following factors would tend to lower possible radium-226 concentrations in the reservoir:
>
> "1. Release of 100% of the contents of a slime pond id not probable.
>
> "2. Proposed slime storage at this facility is located on the drainage basin of the Myakka River, not on the Manatee River.
>
> "3. A system of secondary dams is provided...
>
> "4. Clays found at this location show remarkable settling rates. The distance from the property to the head of Lake Manatee is approximately 10 river miles 16.1 kilometers . Since the radium-226 levels are almost entirely associated with the undissolved fraction, concentration would be much lower on entrance to reservoir."

The phosphate industry's mining and beneficiation activities that would tend to increase airborne radioactivity over what might otherwise exist center on the disturbance of materials in the mine area, thereby freeing more radon-222 gas to the atmosphere, and to a much lesser extent on the dust created by relocating equipment or support vehicles over roads built of mined materials. No quantitative acceptable measure of increased airborne radionuclide concentrations caused by mining operations can be found. Ascribing atmospheric radiation levels to a specific source in an open environment would be highly suspect without ccpious measurements.

Guidmond (1977) summarized radioactivity concentrations in the products of beneficiation (Table 4.8) wherein the values for radium-226 and uranium-238 were consistent with those of Figure 4.4.

Table 4.8. Natural Radioactivity Concentrations in Florida Phosphate Mine Products and Wastes*

Material	Picocuries per Gram				
	Ra-226	U-238	U-234**	Th-230	Th-232
Marketable rock	42	41	41	42	0.4
Slimes	45	44	42	48	1.4
Sand tailings	8	5	5	4	0.9

*Guimond (1977)
**Guimond et al (1975)

Radioactivity concentrations of thorium (thorium-230 being a daughter product of uranium-238 and throium-232 the progenitor of the thorium decay series) also were given. Of the throium materials, throium-230 is of greater important to the study; as well be shown later, this radionuclide ends up in fertilizer products, as does uranium-234.

If the matrix has a radium-226 concentration of approximately 50 picocuries per gram (a high value), the corresponding gamma dose rate in air over pure matrix would be approximately 92 microroentgens per hour which would cause a dose of 184 millirem per year if the exposure were 2000 hours (40 hours per week for 50 weeks) (Florida Department of Health and Rehabilitative Services 1975). Over sand tailings, the exposure would equal about 29 millirem per year.

Another mining-associated activity involving the redistribution of radionuclides is dewatering of the mine area. This process normally uses pit pumps discharging to surface ponds or streams. At same locations, connector wells are also used to drain the water-table water and the uppermost water of the upper Floridan.

aquifer (as it occurs at least through the base of the matrix) into the lower Floridan; thus, radionuclides in the upper waters are mixed with those in the lower waters. Using two basic data holdings, USGS 1966 and EPA 1973-76, Kaufmann and Bliss (1977) presented summary data on radium-226 concentrations of such waters. These data, repeated in Table 4.9, indicate that water of the water-table aquifer has a lower radium-226 concentration (mean value at 0.92 picocuries per liter) than does water in the lower Floridan aquifer (1.44 picocuries per liter).

Table 4.9. Radium-226 Concentrations in Ground Water in Mined Regions of Central Florida*

Aquifer		Picocuries per Liter	
		EPA('73-76)	USGS('74-76)
Water Table	No.	4.0	12.0 **
	Mean	2.8	0.55
	SD	1.65	3.3
	Range	2.0-5.3	0.20-4.40
Upper Floridan	No.	No data	10.0 **
	Mean		1.61
	SD		2.0
	Range		0.16-6.0
Lower Floridan	No.	6.0 **	7.0
	Mean	1.96	4.49
	SD	1.33	6.51
	Range	0.13-3.5	0.14-14.0

*Kaufmann and Bliss (1977)
**Data set used in analysis by authors.

2. Processing

a. Manufacturing

The manufacture of sulfuric acid used by the phosphate industry in the production of phosphoric acis has been discussed in Volume I of this series of working papers. Because the raw sulfur used is essentially devoid of radionuclides, this activity of the phosphate industry in the study area creates no radiation hazards.

Predominantly, the manufacture of ferfilizers begins with the drying of phosphate materials received from the beneficiation process and the subsequent grinding of the materials to improve reactivity in the chemical processes that follow. The materials are dried in large rotary kilns fired by fossil fuels;

grinding operations predominantly employ ball mills. Although the rock dryers are usually equipped with dry cyclone dust traps, after which wet scrubbers are used, and the grinders usually have baghouse dust collectors (Patridge et al 1977), drying and grinding release airborne fine dust particulates containing small concentrations of radionuclides. The radioactivity levels of the ground materials and the released dust are essentially those given earlier for marketable phosphate rock. Of the two activities, drying realeases more particulate matter. During drying, large quantities of hot gases mix with the materials to be dried and tend to entrain particulates, making full containment of these extremely difficult; in grinding, however, airborne particulates are much more manageable because of the much lower volume and speed of pass-through gases. In one operator's air emmissions report for 1976, it was stated that rock drying released 45 tons of particulate matter per year compared with rock grinding's release of 3.5 tons per year. For this reason Partridge et al (1977), in their study of the radioactivity of particulates released by the phosphate industry, concerned themselves with drying operations. They measured the radioactivity of various radionuclides in particulate emmissions and found their balance to be equal to that of the original phosphate rock, as expected. Radiation dose projections were shown to be small for airborne particulate radioactivity released by the phosphate industry, with drying operations the most significant of all operations. Patridge et al gave the maximum calculated radiation dose level to the lung from particulate matter inhaled at a range of 400 meters (1320 feet) from a dryer processing approximately 2,000,000 tons of wet phosphate rock as 48 milirem per year. Calculated maximum individual dose to the nearest residence was given as 13 millirem per year.

Fertilizer manufacturing next involves treating dried and ground feed materials with sulfuric acid to produce phosphoric acid. Figure 4.5 shows the production flow of a wet-process phosphoric acid plant and gives typical concentrations of uranium-238 (assume an equal concentration of uranium-234) and radium-226 in picocuries per gram except for phosphoric acid where concentrations are expressed in picocuries per liter. Gross radioactivity balancing of the input phosphate rock and the output products of the wet-process operations indicates that approximately 1 percent of the radium-226, 60-80 percent of the thorium-230, and 80 percent of the uranium (U-238 and U-234) are dissolved during acidulation by sulfuric acid (Guimond and Windham 1975). Mills et al (1977) reported samples of phosphoric acid that contained about 1000 picocuries per liter of radium-226 but 50,000-100,000 picocuries per liter of uranium-238. Uranium-234 concentrations presumably track those of uranium-238 because of their virtually identical chemical properties.

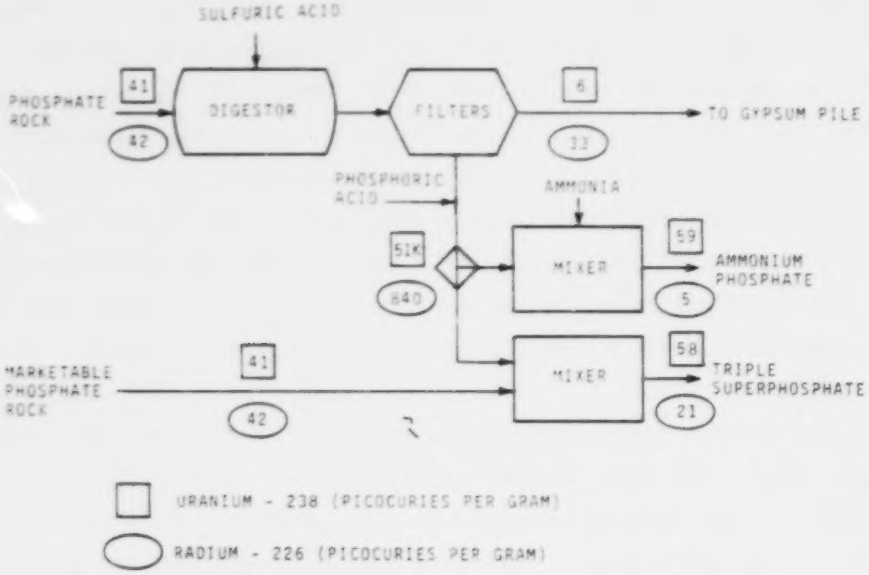

SULFURIC ACID
PHOSPHATE ROCK
41
42
DIGESTOR
FILTERS
6
33
TO GYPSUM PILE
PHOSPHORIC ACID
AMMONIA
51K
840
MIXER
59
AMMONIUM PHOSPHATE
5
MARKETABLE PHOSPHATE ROCK
41
42
MIXER
58
TRIPLE SUPERPHOSPHATE
21
URANIUM - 238 (PICOCURIES PER GRAM)
RADIUM - 226 (PICOCURIES PER GRAM)

Figure 4.5. Production Flow of Wet-Process Phosphoric Acid Plant (Guimond 1976a)

According to Guimond (1977),

> "Ammonium phosphates were observed to have radium-226 concentrations of about 5 pCi/gram. Uranium concentrations were a factor of 10 greater than radium-226 concentrations. The relatively low radium-226 concentration and much higher uranium concentration was attributed to the fact that production of ammonium phosphates uses only ammonia and phosphoric acid with no direct reaction with phosphate rock. Consequently, the bulk of the radioactivity introduced to the reaction comes from the phosphoric acid which is enriched with uranium and deficient in radium-226.
>
> "Concentrated superphosphate contained about 4 times as much radium-226 and about the same concentration of uranium as ammonium phosphate fertilizer. This is because concentrated superphosphate is produced by acidulating phosphate rock with phosphoric acid. Therefore, the product, triple superphosphate (TSP), would be expected to display a compromise activity corresponding to the reactant mix, phosphate rock and phosphoric acid."

Table 4.10 summarizes the natural radioactivity concentrations in fertilizer materials made from Florida phosphates.

Table 4.10. Natural Radioactivity Concentrations in Fertilizer Materials Made from Florida Phosphates*

Material	Picocuries per Gram**				
	Ra-226	U-238	U-234†	Th-230	Th-232
Normal superphosphate	21.3	20.1	***	18.0	0.6
Diammonium phosphate	5.6	63.0	63.0	65.0	0.4
Concentrated superphosphate	21.0	58.0	-	48.0	1.3
Monoammonium phosphate	5.0	55.0	55.0	50.0	1.7
Phosphoric acid (29% acid)	< 1.0	25.3	-	28.3	3.1
Gypsum	33.0	6.0	6.2	13.0	0.3

*Guimond (1977)

**Except phosphoric acid, which is in picocuries per liter.

†Guimond and Windham (1975)

***Equality with U-238 could be assumed.

Animal feed supplement was reported by Guimond and Windham (1975) to contain about the same radium-226 concentration as ammonium phosphate, and sodium fluosilicate was reported to contain very little radium-226. The latter indicates that byproduct fluosilicic acid would contain little radium-226. Guimond and Windham did not analyze uranium and thorium concentrations.

Elemental phosphorus is produced by calcining phosphate rock in electric furnaces and is used to produce high-purity phosphoric acid and phosphate chemicals satisfying industrial and chemical needs. Elemental phosphorus is not a significant fertilizer source. Giumond and Windham (1975) averaged the radium-226 concentrations of the input and output materials in the elemental phosphorus production process at two plants using Florida ore. Table 4.11 presents those values. According to Guimond (1977), "our ability to mass balance the input and output of radium-226, uranium-238, and thorium-230 to within about 10 percent suggests that the bulk of these radionuclides present in the marketable ore is transferred to either the fertilizer products or the phosphogypsum waste during processing. This implies that at least large quantities of these radionuclides are not released to the environment through air

Table 4.11. Radium-226 Concentrations in Elemental Phosphorus Production*

	Material	Picocuries per Gram
Input	Feed ore	60
	Coke	1
	Gravel	0.5
Output	Elemental phosphorus	
	Slag	56
	Ferrophosphorus (FEP)	1.2

*Guimond and Windham (1975)

emissions from fertilizer plants." This is confirmed by Partridge et al (1977), who conclude that "dose projections ... show the small magnitude of airborne particulate radioactivity released from the phosphate industry operation." Partridge et al (1977) measured radioactivity levels statistically above background in only 5 of the 12 locations sampled — and these were within 750 meters (2460 feet) of the respective plants; their summary data on individual radiation dosage from three segmented operations of the industry, i.e., one dryer plant and two wet-process phosphoric acid plants, appear in Table 4.12.

Table 4.12. Individual Radiation Dose from Phosphate Industry Plants*

	Maximum		Nearest Residence	
	Range [m (ft)]	Lung Dose (mrem/yr)	Range [m (ft)]	Lung Dose (mrem/yr)
Dryer plant	400 (1,312)	48	400 (1,312)	13
			840 (843)	8
Wet Plant A	400 (1,312)	2.8	800 (2,625)	1.6**
Wet Plant B	400 (1,312)	110	1,860 (6,103)	11
			2,700 (8,859)	1

*Partridge et al (1977)

**The nearest residence would receive much less than 1 mrem/yr.

Windham et al (1976), surveying several fertilizer manufacturing facilities in Florida and North Carolina to determine the radiation dose equivalent received by industry workers, concluded that only two pathways for exposure were significant: the external radiation exposure from gamma radiation and the dose received by inhaling airborne radionuclides. According to those investigators:

> "External gamma exposures to personnel were measured using thermoluminescent dosimeters, pressurized ionization chambers, and portable scintillation-type survey instruments. High-volume air samplers were used to collect airborne particulates on paper filters. These filters were analyzed to determine concentrations of airborne particulates, which were subsequently used to compute potential radiation dose equivalents."

Table 4.13 presents the thermmoluminescent dosimeter (TLD) measurements of Windham et at (1976), Table 4.14 displays their pressurized ionization chamber (PIC) and scintillation counter (scintillator) measurements, and Table 4.15 presents the maximum gamma dose rates encountered during their survey.

Table 4.13. Thermoluminescent Dosimeter Measurements*

Location	Avg Exposure (μR/hr)
Background, Dundee, Fla.	4
Background, Lake Wales, Fla.	6
Background, Polk City, Fla.	4
Grounds, general office	14
Parking lot, general office	6
Ore unloading	19
Ore unloading	38
Ore unloading	54
Ore unloading	39
Ball mill area	37
Phosphoric acid plant	179
Fertilizer plant	7
Fertlizer product storage	16
Fertilizer product storage	16
Furnace area, thermal process plant	65
Ore drying and storage	57

*Windham et al (1976)

Table 4.14. Pressurized Ionization Chamber (PIC) and Scintillator Measurements*

Area of Measurement	PIC (μR/hr)	Scintillator (μR/hr)
Washing and beneficiation facility	No data	52
Ore drying and storage	90	105
Ore unloading	100	115
Ball mill area	19	22
Phosphoric acid plant		
General area around reactor	132	85
Inside reactor during cleanout	No data	500
Fertilizer building	10	10
Product storage area		
Dry fertilizer products	12	15
Slag and ferrophosphorus	No data	150
Top of gypsum pile	No data	30
General area around thermal process plants	No data	75

*Windham et al (1976)

Table 4.15. Maximum External Gamma Doses*

Area of Plant	Dose Equivalent Rate ** (mrem/yr)
Wet process	
Ore drying and storage area	120
Ore unloading area	60
Ball mill area	70
Phosphoric acid building	40
Fertilizer production building	10
Product storage and shipment area	30
Top of gypsum pile	60***
Inside reactor (during cleanout)	160***
Thermal Process	
Ore unloading area	110
Furnace area	130
Ferrophosphorus and slag storage area	300***
General plant area	100***

*Windham et al (1976)

**Based on occupational exposure.

***Based on PIC or scintillator measurements.

Windham et al (1976) used two different methods to calculate potential lung doses due to inhalation of radioactive particulates of radioactive materials: one, as reported by the International Commission of Radological Protection Report No. 2 (USEPA 1974a) and the other, as reported by the Environmental Protection Agency in Environmental Analysis of the Uranium Fuel Cycle Part 1 - Fuel Supply (USEPA 1973). Lung doses of phosphate workers in the wet-process plants calculated using the two models appear in Table 4.16, while those for thermal-process plant workers are given in Table 4.17. Tables 4.18 and 4.19 summarize airborne and direct radiation doses at the wet-process and thermal-process plants respectively.

Table 4.16. Lung Doses Calculated at Wet-Process Plants*

Location	ICRP (mrem/yr)**	EPA (mrem/yr)**
Ore unloading area	1,600 (530-3,600)	5,500 (1,800-9,000)
Dryer area	300 (110-660)	1,000 (330-2,200)
Ball mill area	1,100 (940-1,400)	3,600 (3,000-4,700)
Fertilizer production building	900 (320-2,100)***	2,500 (850-6,000)
Product storage and shipment Area A	1,000 (160-1,900)	3,200 (470-5,500)
Product storage and shipment Area B	50 (20-90)	150 (60-270)
Top of gypsum pile (radon plus daughters only)	3,000	1,000+
Inside reactor during cleanout	240 (240-250)++	700 (660-740)+++

*Windham et al (1976)

**Based on 40 hours per week, 50 weeks per year. Two or more samples averaged, with range in parentheses.

***Includes 110 mrems for polonium-210.

+Assumes 3-minute build-up of radon daughters with pure radon initially.

++Includes 240 mrems for radon and its daughters; occupancy assumed to be 8/50th of a year.

+++Includes 660 mrems for radon and its daughters; occupancy assumed to be 8/50th of a year.

Table 4.17. Lung Doses Calculated at Thermal-Process Plants*

Location	ICRP (mrem/yr)**	EPA (mrem/yr)**
Ore unloading area	2,300	6,000 (5,500-6,500)*
Beneath ore storage bins	90	280
Furnace area	270	850

*Windham et al (1976)

**Doses based on 40 hours per week, 50 weeks per year. Two or more samples averaged, with range in parentheses.

Table 4.18. Summary of Airborne and Direct Radiation Doses at Wet-Process Plants*

Location	Airborne Dose Equivalent (mrem/yr)**		Direct Gamma Dose Equivalent (mrem/yr)**
	ICRP	EPA	
Ore unloading area	1,600	5,500	60
Ball mill area	1,000	3,600	70
Fertilizer production building	900	2,500	10
Product storage and shipment area	1,000	3,200	30
Top of gypsum pile (radon plus daughters only)	3,000	1,000	60
Inside reactor during cleanout (radon plus daughters included)†	200	700	160

*Windham et al (1976)

**Doses based on 40 hours per week, 50 weeks per year.

†The reactor vessel is normally cleaned 4-8 times per year by 20-40 personnel; each cleaning takes approximately 5-7 days. Doses based on occupancy of vessel for eight cleanouts, each lasting 40 hours, during year.

Table 4.19. Summary of Airborne and Direct Radiation Doses at Thermal-Process Plants*

Location	Airborne Dose Equivalent (mrem/yr)** ICRP	Airborne Dose Equivalent (mrem/yr)** EPA	Direct Gamma Dose Equivalent (mrem/yr)**
Ore unloading area	2,300	6,000	110
Beneath ore storage bins	100	300	No data
Furnace area	300	900	130
Ferrophosphorus and slag storage area	No data	No data	300
General plant area	No data	No data	100

* Windham et al (1976)

** Based on 40 hours per week, 50 weeks per year.

From their data, Windham et al (1976) conclude that:

> "All measured direct gamma exposures were below the recommended guideline of 0.5 rem [500 mrem] per year for individual members of the general population. All estimates of lung doses were below the current guidance for radiation workers, and in most cases are below the 1.5 rem [1500 mrem] per year guidance for an individual member of the general population."

b. Waste Placement and Treatment

The primary waste from wet-process phosphoric acid plants is calcium sulfate that is precipitated in the reaction between sulfuric acid and phosphate rock. The wet process, as used in the study area, precipitates calcium sulfate dihydrate ($CaSO_4 \cdot 2H_2O$, gypsum), which collects on the filters (as filter cake) and is flushed off by process waters; these acidic waters ($pH \leq 2$) are circulated to the gypsum pond/stack where the gypsum and other solid wastes in the stream tend to settle. From the stack, the process water circulates to large cooling reservoirs from which the water is returned to the plant for reuse or, in rare cases of extremely heavy rainfall, is treated and released. The exothermic (heat-producing) reaction of phosphate rock, sulfuric acid, and water essentially destroys the secular equilibrium between uranium-238 and its daughter products. The bulk of the radium-226, for example, ends up in the gypsum stack as calcium-radium sulfate, while uranium and thorium predominantly associate with the phosphoric acid and end up in fertilizer products, although phosphorus, fluorine, uranium, thorium, and other trace elements are found in both the phosphoric acid and the gypsum stack. Figure 4.6 shows the water flow and waste treatment (liming) points at a typical wet-process plant.

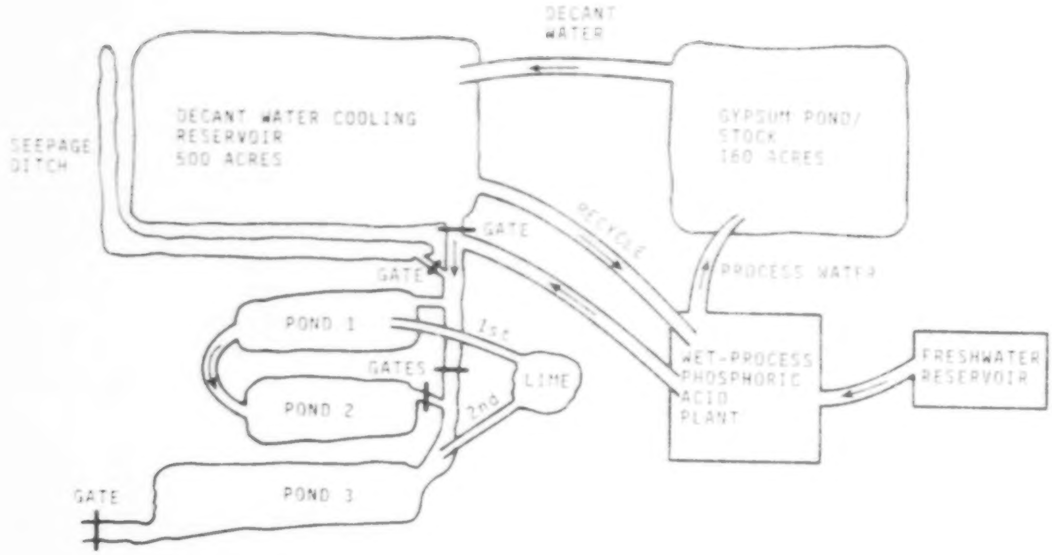

DECANT WATER
DECANT WATER COOLING RESERVOIR 500 ACRES
GYPSUM POND/ STOCK 160 ACRES
SEEPAGE DITCH
GATE
RECYCLE
GATE
PROCESS WATER
POND 1
1st
GATES
LIME
WET-PROCESS PHOSPHORIC ACID PLANT
FRESHWATER RESERVOIR
POND 2
2nd
GATE
POND 3

Figure 4.6. Water Flow and Double-Liming Inputs of Typical Wet-Process Plant (Mills 1974)

According to Mills et al (1977):

> "To prepare process water for discharge to the environment, the pH must be increased from 1.5-2.0 to 6-9. To accomplish this, slaked lime is normally added to the discharge water in a step called 'double liming'. Our studies have shown that this treatment is highly effective in removing radionuclides from the effluent. Radium-226 reduction of greater than 96 percent were observed in all situations studied. Similar reductions in uranium and thorium were also observed."

Under laboratory conditions (Guimond and Windham 1975), liming of process water resulted in soluble radium-226 concentration reduction by more than 99.7 percent; an early field study that they conducted at several wet-process phosphoric acid production facilities in central Florida demonstrated the value of the method in removing radionuclides from effluents. The data are presented in Table 4.20. Radionuclide concentrations in gypsum itself appear in Table 4.10.

Table 4.20. Effect of Lime Treatment in Radioactivity Removal from Wet-Process Phosphoric Acid Plant's Effluents*

				Total Uranium (pCi/l)			Total Thorium (pCi/l)		
	Sample	pH	Total Radium-226 (pCi/l)	-234	-235	-238	-228	-230	-232
Survey 1	Untreated process water	2.0	82.3	1,086	48	1,045	2.5	70	4.5
	Outfall (after double liming)	9.1	4.54	1.09	ND	0.52	0.44	0.57	0.04
Survey 2	Untreated process water	1.8	55.6	411	24	394	3.4	101	3.2
	Limed (once) water	4.4	1.20						
	Water prior to second liming	4.3	1.5	39.7	2.2	39.5	ND	0.52	ND
	Outfall (after second liming)	7.1	1.8	16.8	0.98	16.8	0.32	0.71	0.11

*Guimond and Windham (1975).

The Environmental Protection Agency (USEPA 1974b) calculated the radiation impact of radium-226 in the effluents of the phosphate industry in the study area. The following were the assumptions:

- The Alafia River is the critical waterway because five phosphate facilities discharge into it.

- The precipitation area-to-evaporation area ratio for each facility is 3.27:1.
- The annual excess precipitation over evaporation is 25.4 centimeters (10 inches), the excess occurs over a 2-month period, and the entire excess precipitation must be released.
- The average process water pond is 1000 acres (a high value).

With the water being released continuously, these assumptions yield a monthly excess water release of 1.68 x 10^9 liters for each of the five plants.

Additional assumptions were as follows:

- The Alafia River's average flow rate is 5.09 x 10^6 liters per minute.
- Release rate from the five plants equals 19.4 x 10^4 liters per minute.
- The resultant dilution factor equals 26.
- Average radium-226 concentrations in the effluent is 9.0 picocuries per liter. (See Table 4.20 for measured concentrations.)

From the data, the average added concentration of radium-226 to the Alafia River was 0.35 picocuries per liter.

The EPA further assumed that approximately 15,000 people in the area might drink the water of the river. Thus, the five facilities would yield a total individual exposure of 0.34 millirem per year and a total population exposure of 5.2 man-rem (bone surface). Although the radium-226 concentration of 9.0 picocuries per liter exceeds the safe drinking-water guideline, there are no withdrawals of water for consumption at the point of discharge until considerable dilution has occurred. "Clearly, at an effluent radium-226 concentration of 9 pCi/l," says the EPA staff (USEPA 1974b), "the impact of the releases are well within proposed water-quality criteria for municipal water intake."

Waste from phosphate rock thermal processing is predominantly slag, which can be called a byproduct. Figure 4.7 illustrates radium-226 and uranium-238 concentrations in materials at an elemental phosphorus plant using Florida ore. According to Guimond (1976b), there are indications that significant quantities of polonium-210 may be emitted from these facilities during calcining or furnace operations; he also suggests that calcining operations at wet-process phosphoric acid plants may be volatilizing polonium-210 and releasing it to the environment, but there are no data with which to verify the contention. (See Tables 4.17 and 4.18 for radiation dose levels at these facilities.)

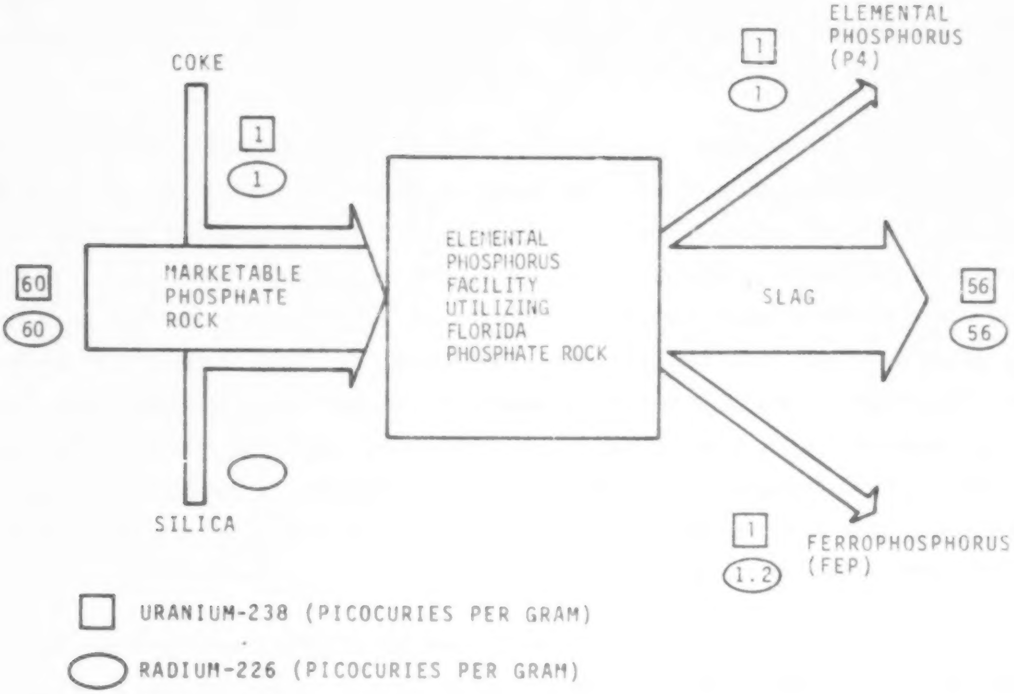

COKE
1
1
60
60
MARKETABLE PHOSPHATE ROCK
ELEMENTAL PHOSPHORUS FACILITY UTILIZING FLORIDA PHOSPHATE ROCK
SILICA
1
1
ELEMENTAL PHOSPHORUS (P4)
SLAG
56
56
1
1.2
FERROPHOSPHORUS (FEP)
URANIUM-238 (PICOCURIES PER GRAM)
RADIUM-226 (PICOCURIES PER GRAM)

Figure 4.7. Production Flow and Concentrations of Uranium-238 and Radium-226 at Elemental Phosphorus Facility (Guimond 1976a)

c. Facilities Construction

Redistribution of naturally occurring radionuclides caused by the by the phosphate industry's construction of facilities would be insignificant. The radium-226 content of soils in the area is about 1.5 picocuries per gram, for example, and sand that might be used in construction probably would have less (Florida Department of Health and Rehabilitative Services 1975).

d. Land Reclamation

The amount of mined but unreclaimed land has been variously estimated to be between 52,650 and 30,375 hectares (130,000 and 75,000 acres) (Bertke 1977, Mills et al 1977 respectively) and reclaimed phosphate land to be between 12,150 (in the past 10 years) and 10,120 hectares (30,000 and 25,000 acres) (Mills 1977, Florida Phosphate Council 1976 respectively).

Not all reclaimed land in the study area can be expected to have the same radionuclide concentrations. As would be the case of most mines in Polk County, for example, mined lands reclaimed through the use of overburden and leach-zone materials (see Figure 4.3) would have considerably different radionuclide concentration near the surface than that reclaimed by the use of overburden materials only (as would be the case where the leach zone may be thin or absent altogether). Another variable would be whether the reclaimed land had been "top-dressed" with soil saved for that purpose; Williams et al (1965) state that radon-222 diffusion mechanisms in soil are thought to predominate near the surface, with most of the gas from depths of 150-160 centimeters (4.9-5.2 feet) or less escaping to the air.

The Florida Department of Health and Rehabilitative Services (1977), evaluating nearly 1000 structures in the area in and around the Bone Valley phosphate deposit, measured instantaneous gamma radiation dose levels and both long- and short-term alpha radiation doses inside and outside structures existing on unmined land with no known phosphate deposits, unmined land with known phosphate deposits, phosphate-mined land that has been reclaimed, and land of unknown type. Some of the findings of this report were fully expected. For example, the correlation factor (r) between radium-226 concentrations in soil and the ambient gamma dose rates in air was found to equal 0.96 for 1.25 microroentgens per hour of gamma dose per 1 picocurie per gram of radium concentration. (This compares to 1.85 microroentgens per hour per picocurie per gram cited by the Florida Department of Health and Rehabilitative Services (1975) and the 2.50 microroentgens per hour per picocurie per gram anticipated by the authors.) The department states that "this effect is probably related to the lack of uniformity of soil radium-226 concentration with depth." Radon-222 emanation as a function of radium-226 concentration in soil yielded a poorer correlation (r = 0.70). "The conclusion drawn from these data is that while gamma exposure rates in air may be utilized as a predictor of radium concentration in surface soil, the concentration of radium in surface soil is a poor predictor of radon-222 emanation rates." The correlation of radon-222 emanation rate as a function of gamma exposure rates in air was poor (r = 0.33). Therefore, gamma exposure rates could not be used to predict radon-222 emanation rates. According to the department, correlation of working-level concentrations of radon-222 in structures with outside air gamma exposure rates also was poor. The study also showed that gamma exposure rates inside structures exceeded by 1 microroentgen per hour those recorded outside in only 0.1 percent of the structures tested, indicating that construction materials used in the area did not constitute an important source of gamma radiation exposure.

Determinations of gamma dose rates both inside and outside structures built on the four land categories in the area are given in Table 4.21; they represent values from which normal background radiation, e.g., cosmic radiation, was not subtracted. None of the structures studied indicates action to provide protection against gamma radiation levels since all of the values are less than 0.05 milliroentgen per hour, the "no action" limit quoted by the surgeon general (Peterson 1970).

In Figure 4.8, the percentage of samples taken over both reclaimed land and land having no known phosphate deposit is shown as a function of measured gamma radiation dose rates in air. The distributions appear to be different; however, the data show heterogeneous variances, an "equality hypothesis" for the means of the two data sets that can be rejected at the 95 percent confidence level, and statistical difference impossible to prove. For comparison, the authors provided information on natural background in which the cosmic-ray contribution to exposure in air in Florida was shown to be 3.6 microroentgens per hour and the contribution of limestone and sandstone to be 2.7 and 6.0 microroentgens per hour respectively.

Table 4.21. Gamma Radiation Dose Rates in Structures in and near 7-County Study Area[*]

		Distribution					
		Mean Outside, Each Location			Mean Inside, Each Location		
Percent of Total Sample	Land Class[†]	Number of Locations	Mean (μR/hr)[‡]	Standard Deviation (μR/hr)[*]	Number of Locations	Mean (μR/hr)[‡]	Standard Deviation (μR/hr)[‡]
2	U	21	8.1 ± 0.6 (5.0 - 14.0)	2.7	21	7.4 ± 0.5 (5.0 - 12.0)	2.2
3	M	27	6.2 ± 0.2 (5.0 - 10.0)	1.2	27	6.2 ± 0.2 (5.0 - 9.0)	1.0
39	N	392	6.1 ± 0.07 (5.0 - 18.0)	1.5	394	6.0 ± 0.07 (5.0 - 16.0)	1.5
56	R	553	9.6 ± 0.2 (5.0 - 34.0	3.9	554	7.9 ± 0.1 (5.0 - 25.0)	2.8
Total		993	8.1	3.6	996	7.1	2.5

[*] Florida Department of Health and Rehabilitative Services (1977)

[†] U = unknown type
M = unmined, with deposits
N = unmined, no deposits
R = reclaimed

[‡] Range of individual location means in parentheses.

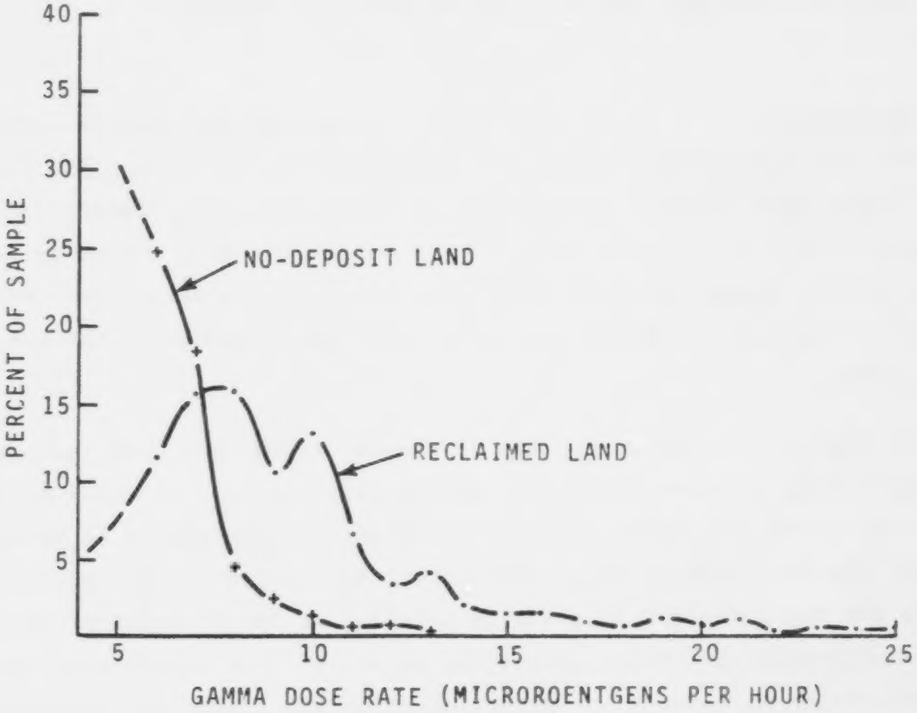


Figure 4.8. Gamma Dose Rate Distribution over Reclaimed and No-Deposit Land (Florida Department of Health and Rehabilitative Services 1977)

In 177 structures in the study area (127 on reclaimed land and 50 on other land classifications) both long- and short-term radon-222 concentrations were measured (Florida Department of Health and Rehabilitative Services 1977); radon-222 concentrations were measured in terms of working levels (WLs) over "running times" of up to 168 hours per deployment. Although the data collected have not been fully analyzed (publication of the final report is planned for January 1, 1978), some generalizations can be made. First, the distribution of WL (working level) concentrations in structures built over reclaimed land and in those built over land with no known deposits is not normal (Figures 4.9 and 4.10). Second, "the null hypothesis that the two distributions are equal must be rejected at the 99 percent confidence level," according to the authors. Third, the WL concentrations in structures built on reclaimed land are statistically higher than in structures built on no-deposit land. Points A and B on the illustrations denote the levels of radon daughter product concentration cited by the surgeon general: i.e., no action is indicated when concentrations are below 0.01 WL* (A), possible remedial action is indicated when they are between 0.01 and 0.05, and remedial action is indicated when they are above 0.05 (B). Approximately 3 percent of structures sampled on reclaimed land would indicate remedial action, approximately 37 percent would indicate possible remedial action, and no action would be indicated for approximately 60 percent. Remedial action might be indicated for approximately 8 percent of the no-deposit structures, with the balance not indicating action. Remedial action in the case of housing structures could include establishing ventilation under the foundation, limiting use of air conditioning, or establishing a regular schedule of ventilating the structure (e.g., by opening windows).

From a health-risk viewpoint, Peterson (1970) cites that radon daughter product exposures of 120 CWLMs (cumulative working level months) will approximately double the risk to lung cancer in the U.S. adult male population. To reach this level of exposure, a 70-year-old male would have had to have continuously lived in a house built on reclaimed land with a continuous WL value of 0.034. This would be possible in approximately 8 percent of the structures studied by the Florida Department of Health and Rehabilitative Services. If more reasonable

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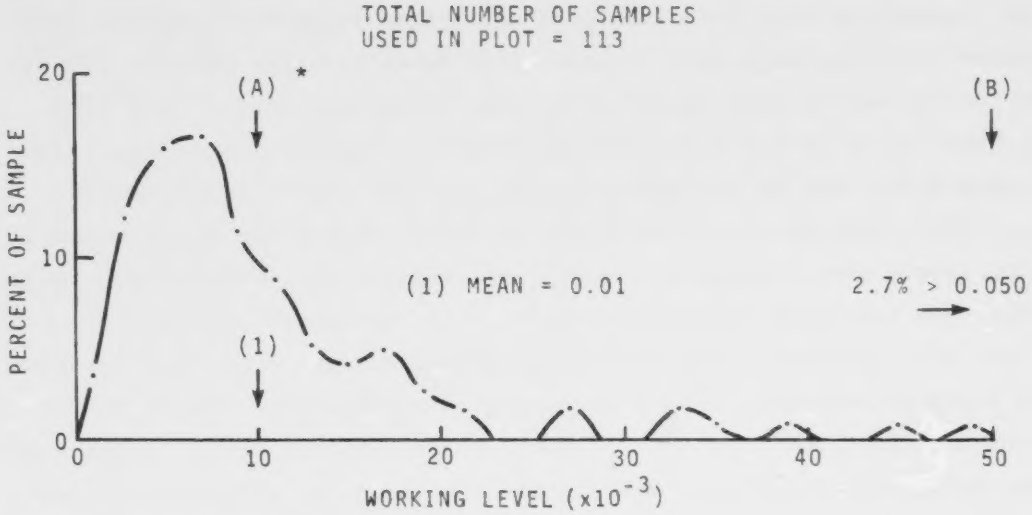
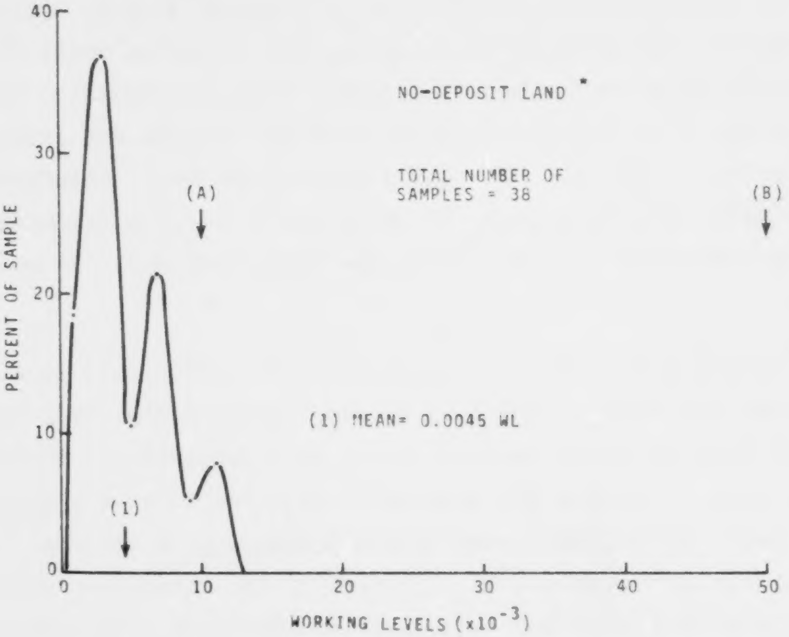
*A value of 0.01 leads to an annual cumulative working-level month value (CWLM) of 0.5, the ICRP- recommended maximum "no-action" level for the general population (Paterson 1970).



*LEVELS REFERENCED IN TEXT

Figure 4.9. Working Levels (Preliminary Data) in Structures on Reclaimed Land (Florida Department of Health and Rehabilitative Services 1977)



*LEVELS REFERENCED IN TEXT

Figure 4.10. Working Levels (Preliminary Data) in Structures on No-Deposit Land (Florida Department of Health and Rehabilitative Services 1977)

values were assumed, i.e., a maximum of 16 hours per day rather than 24 for a working male and a 30-year maximum ownership of the house, the radon daughter concentrations would have to be continuously on the order of 0.12 WL to double the lung cancer risk. No samples by the Florida Department of Health and Rehabilitative Services exceeded that level. It must be reemphasized, however, that the data cited here are preliminary and have not been subjected to thorough analytical evaluation. A 1975 study of radon daughter levels on reclaimed Florida phosphate land (USEPA 1975b) showed values somewhat higher than those revealed in the department study; two of the 21 homes used in the 1975 study had WLs above 0.034, and one of those exceeded 0.12. However, the EPA (1977) states:

> "Based upon the present state of knowledge derived from studies of uranium and other miners exposed to radon daughter products with no adjustments for ages, sex, or other demographic factors, it is estimated that an exposed subject's risk of lung cancer is doubled after an exposure of 30 to 60 cumulative working level months (CWLM). Continuous occupancy [emphasis added] in a structure which has an average indoor radon daughter concentration of 0.02 WL above background for a period of 70 years results in a cumulative exposure of 70 WLM. This exposure is estimated to increase an average individual's risk of lung cancer death by about 60 to 120 percent."

In the 1975 study, 43 percent of the houses on reclaimed land exceeded the 0.02 WL. In the 1977 study, only 8 percent of the houses on reclaimed land exceeded that level. It should be emphasized that these studies had different objectives and that direct comparisons should thus be avoided.

e. Transportation

Industry activities involving transportation of mined and manufactured products alter the radiation environment of the study area. Increases in radiation levels at the various points of materials storage and processing have been previously discussed. Local increases in radiation due to transportation are considered transient and therefore are not evaluated. However, it should be noted that spillage caused by accidents (e.g., pipeline breaks and train wrecks) can change local radiation levels but are too site-specific to be considered here. Normal spillage of phosphate rock along railroad rights-of-way is common but is considered insignificant in an areawide consideration.

D. SUMMARY

From the foregoing, it is apparent that the subject of radiation as it pertains to the environment and the potential for radiobiological impacts in the 7-county study area is complex and susceptible to uncertainties as expressed by scientists in the field as well as the general public. The projection of knowledge of high dose/high dose-rate experience (e.g., Hiroshima and Negasaki) to low dose/low dose-rate experiences (e.g., living in homes constructed on reclaimed phosphate lands) leads to such uncertainties, as does the problem of establishing basic protection criteria at local as well as national and international levels. The National Council on Radiation Protection and Measurements (1971) addressed the latter problem by stating:

> "Working guidance for radiation protection calls for the provision of pragmatic protection recommendations by combining scientific information with conservative application of theory and a need for practicality through the introduction of value judgments. ...It should be noted that the introduction of value judgments is not merely the result of a lack of impeccable scientific data but also the result of using the 'no-threshold' concept. Ultimate scientific proof of the 'no-threshold' postulate, should it ever be accomplished, would almost certainly verify the continued need for value judgments."

Radiation data for the study area have been gathered primarily by the EPA, the Florida Department of Health and Rehabilitative Services, county health departments and the University of Florida (particularly those for Polk County) in response to specific suspected potential health hazards. These spot studies are being followed in some cases with more extensive areawide studies to attempt to further assess the extent and magnitude of any potential problem. At this time, however, data on the radiation environment of the entire 7-county study area are incomplete and additional data are needed before the impact of phosphate industry activities can be precisely evaluated. Thus, the following compilation of information from scientific reports by health-protection organizations and regulatory agencies with responsibilities within the 7-county study area must be considered to be only a first approximation of the local radiation environment, with the realization that closer approximations will be possible only upon completion of extensive areawide radionuclide monitoring programs.

1. Average Background Radiation Environment

- Gamma radiation exposure

  Assume 115 milliroentgens per year (115 millirem per year) for cosmic and terrestrial exposure, an additional 70 millirem per year from medical and dental diagnostic procedures, and an additional 10 millirem per year from home appliances (TV, etc.) and from residual fallout for a total of 195 millirem per year.

- Alpha radiation exposure

  Assume 12 millirem per year from water and 18 from food ingestion for a total of 30 millirem per year.

- Exposure from radon daughter products

  - Outdoors

    Not definable because of high variability due to location, time of day, and weather conditions.

  - Indoors

    In structures on land not associated with phosphate, assume 100 millirem per year (not corrected for background cosmic radiation); in structures on land associated with phosphate (i.e., reclaimed land), assume 225 millirem per year (not corrected for background cosmic radiation).

2. Radium-226 Concentrations

Representative radium-226 concentrations in the environment of the 7-county study area, keyed to specific references, are presented in Table 4.22.

3. Radionuclide Concentration Guidelines

As more knowledge accrues concerning the health effects of low dose/low dose-rate radiation on man, there will be more interest in establishing guidelines to protect workers and the general public from undue association with such ionizing radiation. Of the radionuclides known to exist in the study area, radium-226 and radon-222 (and its daughter products) have been shown to pose the highest potential hazard to man and therefore have received the most attention. To date, however, only a few guidelines specific to existing conditions have been offered. Most existing guidelines deal with radiation workers (which, as defined, excludes phosphate workers) and with the general population. Guidelines for the latter do apply to the study area. Among those which impact the general population are:

- Annual whole-body limits of 500 millirem to an individual in the general population
- Radium-226 and radium-228 in drinking water not exceeding 5 picocuries per liter and gross alpha particle activity not exceeding 15 picocuries per liter
- Effluents from the phosphate industry not exceeding 9 picocuries per liter (an interim guideline)

Also, EPA recently released recommendations of action (draft only) for radiation exposure above background levels in structures constructed on Florida phosphate land. These are:

Indoor Radon Daughter Product Working Level (WL)	Outdoor Gamma Radiation Level (μR/hr)	Recommendation
>0.02	>60	Remedial action indicated
0.005-0.02	3-60	Remedial action may be warranted
<0.005	<3	No action indicated

Currently, there are no federal radiation protection guidelines specific to radium-226 in soil or in materials transported or otherwise handled by phosphate industry workers or in products distributed by the industry. Nor are there any guidelines dealing with the continued use of these products, as might be pertinent in dealing with potential crop uptake of radionuclides originating with fertilizers or with their runoff from fertilized croplands. According to the EPA (1977), "future recommendations may be necessary to address these (and other) aspects if they are shown to be important to public health."

As a reminder, guidelines for protection against ionizing radiation as set forth by the various cognizant agencies normally exclude natural background radiation and deliberate exposure in the healing arts.

Table 4.22. Representative Radium-226 Concentrations in 7-County Study Area Environment

Item	Radium-226 Concentration	Reference
Background soil	1.5 pCi/g	Florida Department of Health and Rehabilitative Services (1975)
Silt	1.1 pCi/g	Florida Department of Health and Rehabilitative Services (1975)
Beach sand	0.9 pCi/g	Florida Department of Health and Rehabilitative Services (1975)
Reclaimed soil	10-30 pCi/g	Mills et al (1977)
Overburden (excluding leach zone)	10 pCi/g	Kaufmann and Bliss (1977)
Leach zone materials	40 pCi/g	Kaufmann and Bliss (1977)
Matrix	40 pCi/g 60 pCi/g	Florida Department of Health and Rehabilitative Services (1975) Guimond and Windham (1975)
Wet phosphate rock	29-34 pCi/g 42 pCi/g	Florida Department of Health and Rehabilitative Services (1975) Guimond (1976a)
Sand tailings	7.5 pCi/g 6.2-8.8 pCi/g	Kaufmann (1977) Florida Department of Health and Rehabilitative Services (1975)
Slime particles	45 pCi/g 33-52 pCi/g	Kaufmann (1977) Florida Department of Health and Rehabilitative Services (1975)
Slime decant water (dissolved fraction)	1-2 pCi/ℓ	Florida Department of Health and Rehabilitative Services (1975)
Slime decant water (undissolved fraction)	33.5-52 pCi/g	Florida Department of Health and Rehabilitative Services (1975)
Mine water	< 1.5 pCi/ℓ	Kaufmann and Bliss (1977)
Ground water	< 1.5 pCi/ℓ	Kaufmann and Bliss (1977)
Slime-pond water	< 2 pCi/ℓ	Kaufmann and Bliss (1977)
Leachate from gypsum pond	60-100 pCi/ℓ	Kaufmann and Bliss (1977)
Gypsum	21-33 pci/ℓ	Kaufmann and Bliss (1977)
Phosphate products (undifferentiated)	42 pCi/g	Kaufmann and Bliss (1977)
Phosphoric acid plant effluent after double liming	1.8-4.5 pCi/ℓ	Guimond and Windham (1975)
Slag from calcination processes	56 pCi/g	Guimond and Windham (1975)
Water-table water (mineralized mined areas)	8.55 pCi/ℓ	Kaufmann (1977)
Upper Floridan water (mineralized mined areas)	1.61 pCi/ℓ	Kaufmann (1977)
Lower Floridan water (mineralized mined areas)	4.49 pCi/ℓ	Kaufmann (1977)
Ammonium phosphates	5-6 pCi/g	Guimond (1976a)
Superphosphates	21 pCi/g	Guimond (1976a)
Phosphoric acid	< 1 pCi/ℓ	Guimond (1977)
Upper Floridan water (unmineralized areas)	5.1 pCi/ℓ	Kaufmann (1977)
Lower Floridan water (unmineralized areas)	1.4 pCi/ℓ	Kaufmann (1977)
Water-table water (mineralized unmined areas	0.17 pCi/ℓ	Kaufmann (1977)
Upper Floridan water (mineralized unmined areas	2.30 pCi/ℓ	Kaufmann (1977)
Lower Floridan water (mineralized unmined areas)	1.4 pCi/ℓ	Kaufmann (1977)

SECTION 5

TERRESTRIAL BIOTA

A. GENERAL

The terrestrial biota of the 7-county (Hillsborough, Manatee, Sarasota, DeSoto, Charlotte, Polk, and Hardee) study area in Florida includes floral and faunal species that are widely distributed in the United States, particularly states east of the Great Plains, as well as those limited to either the southeastern Coastal Plain or the Florida peninsula. The area is a transition zone, with many temperate-zone species reaching their southern limits in the vicinity of the Peace River (Harper 1927).

Peninsular Florida, because of its geographical position, physical shape, and geological history, has been an important area for the evolution and dispersion of the flora and fauna of the southeastern Coastal Plain (Woodruff 1973). Species endemic (peculiar) to the peninsula comprise a comparatively high percentage of existing biota. The biogeographical and ecological significance of the region is further enhanced by the presence of relict populations that took refuge there during recent glaciations; many of these relict species occupy sandhills and sand pine scrub habitat. Recently introduced species also are a distinctive, and in some instances a disruptive, element in the biota of Florida. Because of suitable climatic conditions, Florida is the major point of entry for imported plants and animals, particularly tropical species (Gore 1976). Several of these exotic species are established in central Florida; others are present, although perhaps not yet stabilized.

Shaping the biota of an area are the interaction of species as well as the interaction of environmental factors including topography, soil, water, temperature, sunlight, and lightning (fire). Among the salient features of the Florida environment are large areas of low relief and low elevation, great seasonal differences in rainfall, relatively even temperature, poor drainage, and sand soils (Davis 1943). Elevations, though slight, frequently have a great influence on plant distribution (West and Arnold 1956), which in turn influences the fauna of local areas. Rapid plant growth and quick decay of organic materials in the nonflooded to shallowly flooded sand soil areas are effected by a humid, warm climate and long growing season (Davis 1943). Flora and fauna generally are not affected by extreme cold or extreme heat since the rainy season is in summer, and drought is not an important factor since much of the native flora is adapted to a scarcity of water (Kimball 1965). The influence of the distinctive Florida environment results in a spectrum of biota that is unique within the United States.

A review of local vegetation types, important plant species within the types, and the abundance ratings of the terrestrial vertebrates that are present provides much of the baseline data needed to evaluate the impact of phosphate development on biota in the study area. Within these biotic groups, all species of special status (e.g., endangered, commercial, nuisance) are identified and distributions within the study area noted for these species officially listed as threatened or endangered. Similar information is presented for some of the important terrestrial invertebrates.

Wetlands in the study area are first described as vegetation types, and a later section discusses the ecology of these lowland communities. Important wetlands biota is identified, and the relative productivity of the communities and their overall biological importance are addressed.

B. PLANTS

1. Vegetation Cover

In describing the vegetation of the study area, a land use and land cover classification system comprising hierarchical levels of increasing specificity is followed. The broad categories (Levels I and II) are those adopted by the U.S. Geological Survey (Anderson et al 1976). The more specific categories (Level III), which may be considered habitat types, were selected from several sources including the classification recommended by the Florida Division of State Planning (Florida Division of Administration 1976).

Level II vegetation cover in the study area as of 1973 is delineated on the USGS land use and land cover map (Plate 3) found in the map pocket of this paper. More than a dozen Level II categories in the study area are referable to four Level I divisions: agricultural land, rangeland, forest land, and wetlands. Table 5.1 indicates the areal extent of Level I vegetation cover and water by county in the study area.

Table 5.1. Areal Extent of Level I Vegetation Cover and Water in 7-County Study Area*

County	Hectares (Acres)				
	Agricultural Land	Rangeland	Forest Land	Wetland	Water
Charlotte**	10,729 (26,511)	54,252 (134,054)	5,471 (13,519)	21,586 (53,338)	30,474 (75,301)
DeSoto	75,331 (186,141)	52,610 (129,997)	2,788 (6,889)	29,119 (71,953)	608 (1,501)
Hardee	69,645 (172,091)	58,569 (144,723)	4,573 (11,299)	28,091 (69,412)	384 (948)
Hillsborough	117,476 (290,279)	63,504 (156,916)	15,963 (39,443)	17,495 (43,230)	4,764 (11,772)
Manatee	64,260 (158,783)	95,238 (235,329)	3,639 (8,992)	10,988 (27,151)	5,897 (14,572)
Polk***	100,257 (247,733)	45,594 (112,661)	24,515 (60,576)	59,627 (147,337)	24,484 (60,500)
Sarasota	19,031 (47,025)	81,975 (202,558)	12,700 (31,383)	11,361 (28,073)	800 (1,976)
Total	456,729 (1,128,563)	451,742 (1,116,238)	69,649 (172,101)	178,268 (440,444)	67,411 (166,570)

*U.S. Army Corps of Engineers 1976.

**Does not include southeastern one-third (approximate) of county.

***Does not include eastern one-third (approximate) of county.

The several types of vegetation included in the broad cover categories are formed by characteristic aggregations of plant species. The various aggregations are influenced particularly by topography and drainage features. Since elevation of a few feet or even inches from place to place may have a profound effect on surface water (Davis 1943), the gradation of plant species over a short distance is a striking feature of the study area. Figure 5.1 is a diagrammatic profile illustrating the dramatic changes in characteristic vegetation as a higher dry land sloped to a lower wetland area on a site in DeSoto County.

Management practices also are important in the development of some vegetation types, and these as well as natural factors are considered in the descriptions of the types.

2. Uplands

a. Agricultural Land

Agricultural land may be defined broadly as land used primarily for production of food and fiber (Anderson et al 1976). Agricultural activity is

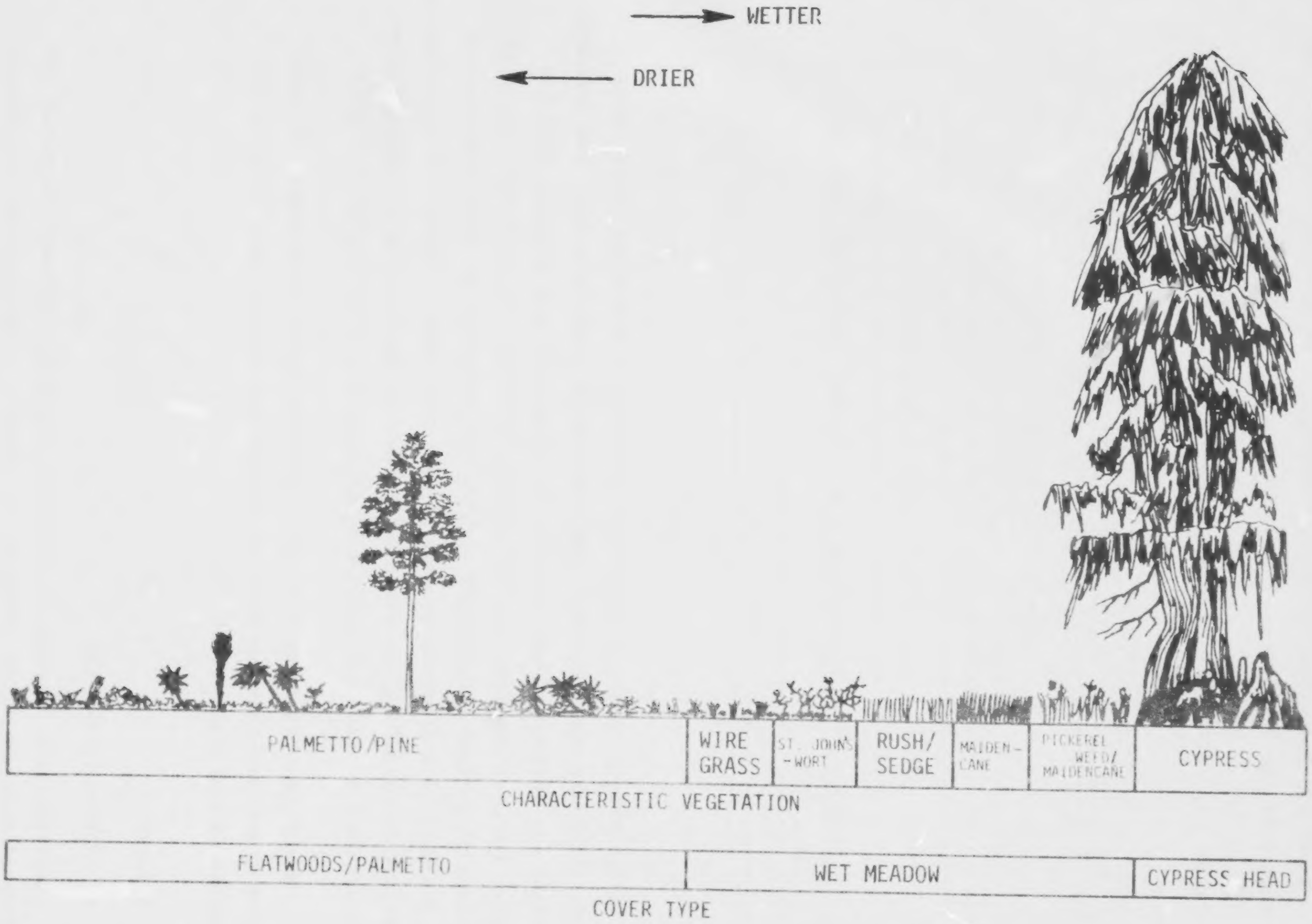

WETTER
DRIER
PALMETTO/PINE
WIRE GRASS
ST. JOHN'S -WORT
RUSH/ SEDGE
MAIDEN- CANE
PICKEREL WEED/ MAIDENCANE
CYPRESS
CHARACTERISTIC VEGETATION
FLATWOODS/PALMETTO
WET MEADOW
CYPRESS HEAD
COVER TYPE

Figure 5.1. Schematic of Change in Characteristic Vegetation from Higher Dry Land to Lower Wet Land on Site in DeSoto County (Texas Instruments 1977)

characterized by distinctive geometric fields and road patterns on the landscape and by traces produced by livestock or mechanized equipment. Agricultural land in the study area displays three Level II categories: cropland and pasture; orchards, groves, vineyards, nurseries, and ornamental horticultural areas; and other agricultural land.

1) Cropland and Pasture

The several components typically included in this category are cropland harvested (including bush fruits), cultivated summer-fallow and idle cropland, land on which crop failure occurs, cropland in soil-improvement grasses and legumes, cropland used for pasture in rotation with crops, and pasture on land more or less permanently used for that purpose. Because of the cyclic nature of many agricultural activities, some of these components may apply to the same segment of land at various times of the year or points in the cycle.

a) Cropland

Several thousand acres in the study area are cropland primarily devoted to fruits and truck crops. Principal crops are tomato, watermelon, cucumber, green pepper, and strawberry. Since many of the crops are grown during the dry season (January-May) and harvested before the wet season, most of this large acreage is irrigated for 4 to 5 months.

b) Pasture

Pastures yield a large part of the food available for Florida cattle. Grasses are the predominant land cover; legumes are second most important. More than 400 grass species are found in Florida, and approximately 332 of these are native (USDA 1974).

Generally, vegetation cover comprising pasture is managed to increase productivity. There has been a continual increase in the quantities of fertilizer applied to pasture, and effective water control systems (irrigation and drainage systems) have been developed. These practices have helped to increase the year-round yields of pasture grasses, generally permitting later grazing in the fall and earlier grazing in the spring.

New grasses have been introduced and native grasses improved. Among the grass species commonly found in improved pastures are the following:

Pangolagrass	*Digitaria decumbens*
Crabgrass, fingergrass, digitgrass	*Digitaria* spp.
Bahiagrass	*Paspalum notatum*
Dallisgrass	*Paspalum dilatatum*
Paspalum	*Paspalum* spp.
Paragrass	*Panicum purpurascens*
Panic grass	*Panicum* spp.
Bermudagrass	*Cynodon dactylon*
Carpetgrass	*Axonopus* spp.
Fescue	*Festuca* spp.

2) Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas

Orchards, groves, and vineyards produce various fruit and nut crops (Anderson et al 1976). Nurseries and horticultural areas, which include floricultural and seed-and-sod areas as well as some greenhouses, are used perennially for growing fruits, vegetables, grasses, or ornamental plants. Tree nurseries that provide seedlings for plantation forestry also are included in the category. The two subcategories recognized in the study area are plantations and parklands.

a) Plantations

Citrus is the major vegetation cover of plantations in the study area. The study area yields oranges (temples and others), grapefruits, tangelos and K-earlys, and tangerines and honey tangerines and in December 1973 accounted for approximately one-third of Florida's citrus acreage (Thompson 1976); about one-half of that was in Polk County. Most of the citrus is intensively managed through irrigation, fertilization, pest control, pruning, and cultivation/mowing.

b) Parklands

This category includes parklands maintained primarily for recreation. Vegetation is mostly managed plantings, often predominantly ornamental horticultural species. Both woody and herbaceous vegetation are usually well represented.

3) Other

The remaining vegetation category to be considered under agricultural land is old fields. This type of ruderal community (areas in which natural flora has been considerably disturbed through man's activities except fire and lumbering) is often described as abandoned agricultural land. During the first year after abandonment, vegetation is composed predominantly of annuals, although some perennials capable of vigorous vegetative reproduction are common. Species composition varies considerably, with a greater number of species occurring on land that has been cultivated for a longer period of time. After 2 or more years of undisturbed growth, perennial herbaceous species dominate, although many annuals persist. Young pines are generally evident at about the fourth year.

Common herbaceous plants in old fields include:

Crabgrass	*Digitaria sanguinalis*
Bermudagrass	*Cynodon dactylon*
Sand-spurs	*Cenchrus* spp.
Ragweed	*Ambrosia* sp.
Cudweed	*Gnaphalium* spp.
Foxtail	*Setaria* spp.
Dog-fennel	*Eupatorium* spp.
Beard-grass, broom-sedge	*Andropogon* spp.
Lovegrass	*Eragrostis* spp.
Galingale	*Cyperus* spp.
Paspalum	*Paspalum* spp.
Panic grass	*Panicum* spp.
Button-weed	*Diodia teres*
Toadflax	*Linaria canadensis*

b. Rangeland

Rangeland historically has been defined as land where the potential natural vegetation is predominantly grasses, forbs, or shrubs and where natural herbivory has been an important influence (Anderson et al 1976). The study area exhibits three Level II categories of rangeland: herbaceous, shrub and brush, and mixed.

1) Herbaceous Rangeland

This category encompasses lands dominated by naturally occurring grasses and forbs, as well as rangelands that have been modified to include grasses and forbs as their principal cover (Anderson et al 1976). Herbaceous rangeland in the study area is typically called dry prairie or palmetto prairie. These prairies usually occur on seldom-flooded sandy soils.

Rangeland vegetation in the study area is characterized by many short grasses, a few tall grasses, and many seasonal herbs. The most abundant grasses are the wiregrasses in the genus *Aristida*. Shrubs, when present, are usually low, with saw palmetto (*Serenoa repens*) the common species. Heath family shrubs such as blueberry also are prominent in these typically acid prairies. Pine trees, if present, are scattered. Essentially, these prairie areas are pine flatwoods without the predominance of pine (Davis 1943). Species characteristic of dry prairies are listed in the discussion of pine flatwoods.

Fire is important in maintaining the general character of the dry prairie. Wiregrasses on recently burned rangelands are grazed extensively, but palatability later declines and cattle seek other forage plants (Hilmon and Hughes 1965). Not only is productivity of wiregrasses enhanced by periodically burning rangelands, but the vigor of saw palmetto is maintained as well, although its growth is checked (Hughes 1975). Succession in dry prairies is retarded, of course, by the periodic fires that are used to maintain grazing conditions. In the absence of fire, shrubs will become more prominent and a shrub and brush rangeland probably will result.

2) Shrub and Brush Rangeland

These so-called eastern "brushlands" are typically former croplands, pastures, or herbaceous rangelands that have become overgrown in shrubs. This brushland is often considered to be in transition back to forest land. Although not used at their former levels of intensity, brushlands usually are grazed often and extensively by livestock. The prominent shrub encountered in brushlands in the study area is wax myrtle (*Myrica cerifera*). Other brushland shrub species, many of which are broadleaf evergreens or tardily deciduous, are listed in the pine flatwoods section.

3) Mixed Rangeland

Vegetation cover is classed as mixed rangeland when there is more than one-third intermixture of either herbaceous or shrub and brush rangeland (Anderson et al 1976). In Florida, this mixed rangeland is called "dry brushland." Its vegetational character is intermediate between herbaceous and shrub and brush rangelands, and species composition is similar to that of other rangeland categories. With time, herbaceous vegetation should become less prominent and woody vegetation more dominant.

c. Forest Land

Forest lands have a crown closure percentage (tree-crown areal density) of 10 percent or more, are stocked with trees capable of producing timber or other wood products, and exert an influence on the climate or water regime (Anderson et al 1976). At Level II, forest land is divided into three categories: deciduous, evergreen, and mixed.

1) Deciduous Forest Land

This category includes all forested areas having a predominance of trees that lose their leaves at the end of the frost-free season or at the beginning of a dry season (Anderson et al 1976). Forest types in this category are usually referred to as hardwoods.

Upland deciduous forest land in the study area is classed into three kinds of hammock: cabbage palm, live oak, and mesic. The term hammock has been used to mean hardwoods, either evergreen or deciduous, having an association with palms (Davis 1940, Laessle 1942); in a more restricted definition which is often used in Florida and will be used here, hammock is a predominantly broad-leaved evergreen association of trees growing on soils seldom if ever subject to flooding (Laessle 1942, Laessle and Frye 1956). Hammocks usually cover small areas. Elevation and the related degree of soil wetness are the primary factors influencing the character of the hammock. Wet (hydric), moist (mesic), and dry (xeric) hammocks can often be distinguished, although intergradation among these is frequent. Hammock forests are often considered to be subclimax or climax.

a) Cabbage Palm

This is a type of low, wet, or hydric hammock (Davis 1940, Laessle 1942, Mohlenbrock 1976) characterized by more or less dense stands of cabbage palm (*Sabal palmetto*) usually mixed with other trees and vines (Frye 1954). The two most important codominant trees in many cabbage palm hammocks are water oak (*Quercus nigra*) and sweet gum (*Liquidambar styraciflua*) (Laessle 1942, Mohlenbrock 1976). The hammock is found on low-lying, poorly drained soils that are nearly saturated with moisture because of seepage of ground water from higher areas. Herbaceous vegetation is often sparse because of the lack of sunlight.

Fire is important in shaping the character of the hammock (Laessle 1942). Some areas may have nearly pure stands of the fire-resistant cabbage palm and almost no fire-susceptible sweet gum and water oak, which are usually associated with the palm. Ivey (1947) states that the dominance by cabbage palms appears to be the result of fires that have burned out all underbrush and hardwood trees.

Important woody and herbaceous plants in cabbage palm hammocks include:

- Woody Species

Cabbage palm	*Sabal palmetto*
Blue palm	*Sabal minor*
Water oak	*Quercus nigra*
Live oak	*Quercus virginiana*
Laurel oak	*Quercus laurifolia*
Sweet gum	*Liquidambar styraciflua*
Florida elm	*Ulmus floridana*
Slash pine	*Pinus elliottii*
Longleaf pine	*Pinus palustris*
Greenbrier	*Smilax* spp.
Poison ivy	*Rhus radicans*
Pignut hickory	*Carya glabra*
Red maple	*Acer rubrum*
Pepper vine	*Ampelopsis arborea*
Swamp redbay	*Persea palustris*
Loblolly bay	*Gordonia lasiantha*
Swamp bay	*Magnolia virginiana*
Black haw	*Viburnum obovatum*
Possum haw	*Viburnum nudum*
Rattan vine	*Berchemia scandens*
Saw palmetto	*Serenoa repens*
Wax myrtle	*Myrica cerifera*
Ilex	*Ilex* spp.

- Herbaceous Species

Carpetgrass	*Axonopus* spp.
Coinwort	*Centella asiatica*
Panic grass	*Panic* spp.
Paspalum	*Paspalum* spp.
Beak-rush	*Rynchospora* spp.
Button snakeroots	*Eryngium baldwinii*
Melochia	*Melochia hirsuta*
Twinflowers	*Dyschoriste oblongifolia*
Musky mint	*Hyptis alata*
Ruellia	*Ruella caroliniensis*
Ferns (several species)	

b) Mesic

Mesic hammocks occur in areas intermediate in soil moisture between the well-drained xeric (live oak) hammock and the nearly saturated cabbage palm hammock. Mesic hammocks commonly contain species common to both of the other hammock types. Two characteristic tree species are southern magnolia (*Magnolia grandiflora*) and American holly (*Ilex opaca*). Ground cover typically is sparse.

Soils of mesic hammocks are richer in organic matter and have a greater water-holding capacity than soils of xeric hammocks. Laessle (1942) suggested that succession proceeded from the xeric hammock to the mesic hammock. This climax community also can be reached on different soil types and through different stages of succession. Fire causes the mesic hammock to regress toward the scrub stage of succession.

Plants commonly occurring in the mesic hammock include:

- Woody Species

Southern magnolia	*Magnolia grandiflora*
American holly	*Ilex opaca*
Laurel oak	*Quercus laurifolia*
Live oak	*Quercus virginiana*
Water oak	*Quercus nigra*
Pignut hickory	*Carya glabra*
Cabbage palm	*Sabal palmetto*
Saw palmetto	*Serenoa repens*
Black cherry	*Prunus serotina*
Redbay	*Persea borbonia*
Blueberry	*Vaccinium* spp.
Ilex	*Ilex* spp.
Lyonia	*Lyonia* spp.
Beautybush	*Callicarpa americana*
Greenbrier	*Smilax* spp.
Wild olive	*Osmanthus americana*

- Herbaceous Species

Panic grass	*Panicum* spp.
Partridge berry	*Mitchella repens*
Nut-rush	*Scleria* spp.
Sedge	*Carex* spp.

c) Live Oak

This xeric hammock type is basically a drier version of the mesic hammock, differing because it lacks a middle tree layer and has a canopy dominated by live oak (*Quercus virginiana*) (Veno 1976). This hammock is typically rather open, with live oaks irregularly spaced, creating many large openings in the leafy canopy (Laessle 1942). Contributing to its xeric nature are well-drained soils containing little organic material; high evaportion loss; and large water uptake by tree roots and Spanish moss (*Tillandsia usneoides*). The shrub layer is low, and herbaceous vegetation is sparse but comprised of numerous species.

Fire plays an important role in this hammock type. In the absence of fire, species characteristic of wet and moist hammocks and of swamp or bayhead communities will invade this xeric hammock. Stages of succession leading to the formation of a live oak hammock may include scrubby flatwoods, sandhills, or sand pine scrub (Laessle 1942).

Characteristic plants of the live oak hammock include:

- Woody Species

Live oak	*Quercus virginiana*
Bluejack oak	*Quercus incana*
Laurel oak	*Quercus laurifolia*
Myrtle oak	*Quercus myrtifolia*
Chapmans oak	*Quercus chapmanii*
Cabbage palm	*Sabal palmetto*
Saw palmetto	*Serenoa repens*
American holly	*Ilex opaca*
Redbay	*Persea borbonia*
Greenbrier	*Smilax* spp.
Blueberry	*Vaccinium* spp.
Dwarf sumac	*Rhus copallina*
Staggerbush	*Lyonia fruticosa*
Beautybush	*Callicarpa americana*
Wild grape	*Vitis* sp.

- Herbaceous Species

Panic grass	*Panicum* spp.
Beard grass	*Andropogon* spp.
Pinweed	*Lechea* sp.
Goldenrod	*Solidago chapmanii*
Golden-aster	*Heterotheca* sp.
Tick clover	*Desmodium canescens*
Partridge pea	*Cassia fasciculata*

2) Evergreen Forest Land

This vegetative category includes all forested areas in which the trees are predominantly those that remain green throughout the year (Anderson et al 1976). In most cases, the coniferous evergreens, referred to as softwoods, predominate.

Evergreen forest land in the study area is classed as pine flatwoods which may be considered to be either scrubby or typical. In this category are several vegetationally distinct communities that are found on a considerable number of soils. Flatwoods occur in areas with flat topography and poorly drained sands. An organic hardpan occurs frequently in many flatwoods.

The pine flatwood forest, which represents the most common vegetation type in Florida, is fire-maintained (Monk 1968); pine may no longer dominate when fire has been prevalent or lumbering has been severe (Laessle 1942).

a) Scrubby

This forest type occurs in scattered patches within the typical flatwoods forest, where there is a slight rise of 0.3 or 0.7 meters (1 or 2 feet) above the general level of the flatwoods (Laessle 1942). Both frequently burned and less frequently burned flatwood forests, representing different origins, are considered scrubby flatwoods. Species composition is similar to that found in typical flatwoods. Scrubby flatwoods are dominated by pine, with a prominent understory of small scrub oaks and other woody shrubs (Garren 1943). Among the scrubby oak species are dwarf live oak (*Quercus minima*), running oak (*Q. pumila*), Chapmans oak (*Q. chapmanii*), and myrtle oak (*Q. myrtifolia*). Wiregrass (*Aristida stricta*) is plentiful.

The exact origin of the scrubby forest type remains unclear. Once the shrub oaks gain a foothold, as may happen following lumbering or on exceptionally dry, sandy sites, they are maintained and increased by continued frequent burning. Scrub oaks are seldom killed by fire but continue to sprout when the tops are repeatedly killed (Garren 1943). Soils are usually well-drained and have an organic hardpan at the water table. Following a 1- or 2-year absence of fire, flatwoods pass from a stage of predominantly annual species into a stage of predominantly perennial vegetation (Frye 1954). Perennial species, many of which are woody, become more and more predominant as the number of years without fire increases, but the number of individual plants usually decreases. The character of the forest after a few fire-free years is that of a dense scrub dominated by fire-resistant shrubs.

b) Typical

The only common tree in this forest is the longleaf pine (*Pinus palustris*), which is more fire-resistant than slash pine (*P. elliottii*) and dominates the drier sites within typical flatwoods (Laessle 1942, Garren 1943, Monk 1968). The trees may be scattered or in dense stands, and their open canopy allows considerable light to penetrate and a dense ground cover to develop.

Fire is tremendously important in shaping the character of the longleaf pine flatwoods, as pointed out by Garren (1943) who concluded that fire is the main factor responsible for perpetuation and maintenance of the species in its typical forest stands. Also, the frequency of fire greatly influences the density and composition of the shrub layer, which is characterized by saw palmetto, *Ilex* species, scrub oaks, and a variety of heaths (Ericaceae) (Edminster 1963). These evergreen shrubs have growth characteristics that are markedly xeromorphic. The herbaceous layer is rich in species, with wiregrass (*Aristida* spp.) usually the most abundant (Monk 1965). Both the longleaf pine and slash pine flatwoods will give way to hardwoods when fire is eliminated. The type of hardwoods community depends greatly on the wetness of the site.

Plants characteristically found in longleaf pine flatwoods include:

- Woody Species

Longleaf pine	*Pinus palustris*
Inkberry	*Ilex glabra*
Saw palmetto	*Serenoa repens*

Dwarf live oak	*Quercus minima*
Running oak	*Quercus pumila*
Myrtle oak	*Quercus myrtifolia*
Chapmans oak	*Quercus chapmanii*
Huckleberry	*Gaylussacia dumosa*
Greenbrier	*Smilax* spp.
Tar flower	*Befaria racemosa*
Shiny blueberry	*Vaccinium myrsinites*
Wax myrtle	*Myrica cerifera*
St. John's-wort	*Hypericum* sp.
Staggerbush	*Lyonia fruticosa*

- Herbaceous Species

Wiregrass	*Aristida* spp.
Indian-grass	*Sorghastrum secundum*
Panic grass	*Panicum* sp.
Carpetgrass	*Axonopus* spp.
Beard-grass	*Andropogon* spp.
Dropseed	*Sporobolus* spp.
Paspalum	*Paspalum* spp.
Pipewort	*Eriocaulon* spp.
Meadow beauty	*Rhexia* spp.
Marsh pink	*Sabatia* spp.
False foxglove	*Agalinis* spp.

The less fire-tolerant slash pine is generally more restricted to wetter sites within the typical flatwoods (Monk 1968). It is more fire-tolerant than most hardwoods, however. The physical appearance of the slash pine forest is similar to that of the longleaf flatwoods, and species composition is often similar in the two flatwoods types. However, succession of slash pine flatwoods is toward a more hydric stage of development, probably bayhead, and moisture-loving species are often more prevalent. These species include:

- Woody Species

Slash pine	*Pinus elliottii*
Blackberry	*Rubus* spp.
Gallberry	*Ilex coriacea*

- Herbaceous Species

Bear grass	*Andropogon* spp.
Slough grass	*Scleria setacea*
Yellow-eyed grass	*Xyris* spp.
Beak-rush	*Rhynchospora* spp.

3) Mixed Forest Land

This category includes all forested areas in which there are both evergreen and deciduous trees but neither predominates (Anderson et al 1976). When an area has more than one-third intermixture of either evergreen or deciduous species, it is classed as mixed forest land. Within the study area, two types of pine-oak woodlands occur: sandhills and sand pine scrubs.

a) Sandhills

In the sandhill communities, longleaf pine is the solitary species in the canopy top (Veno 1976). Below this broken canopy is a lower layer dominated by turkey oak (*Quercus laevis*). Beneath the oak layer, the shrub layer is poorly developed and the herbaceous layer, dominated by wiregrasses, is often dense, although bare patches of sand may be visible. Several herbaceous legumes usually are present (Harper 1948). Sandhill vegetation typically occurs on rolling topography characterized by a layer of deep, well-drained, weakly washed and sorted sands. On lower and richer soils, bluejack oak (*Q. incana*) may be dominant.

Fire is important to the maintenance of all phases of this forest. The association is physiognomically xeromorphic (Laessle 1942, Laessle and Frye 1956). Nearly all plants have heavily cutinized and hairy leaves or revolute and linear ones or some combination of these. Considerable sunlight and air movement occurs within the forest, and the well-drained soils are excessively leached. In the absence of fire, the sandhills forest would be succeeded by either a mesic or xeric hammock forest (Veno 1976).

Plants characteristic of sandhills vegetation include:

- Woody Species

Longleaf pine	*Pinus palustris*
Turkey oak	*Quercus laevis*
Bluejack oak	*Quercus incana*
Live oak	*Quercus virginiana*
Sand post oak	*Quercus margaretta*
Saw palmetto	*Serenoa repens*
Gopher apple	*Licania michauxii*
Red-root	*Ceanothus microphyllus*
Persimmon	*Diospyros virginiana*

- Herbaceous Species

Wiregrass	*Aristida stricta*
Wiregrass	*Sporobolus gracilis*
Golden aster	*Heterotheca graminifolia*
Prairie clover	*Petalostemon pinnata*
False buckwheat	*Eriogonum* spp.
Panic grass	*Panicum* spp.
Hoary pea	*Tephrosia chrysophylla*
Rabbit bells	*Crotalaria* spp.
Queen's-root	*Stillingia sylvatica*
Elliott's beard-grass	*Andropogon elliottii*
Milkweed	*Asclepias* spp.

b) Sand Pine Scrub

Scrub is the least fertile and one of the most xeric communities in Florida (Monk 1968). This forest is dominated by sand pine (*Pinus clausa*), with a dense shrub layer characterized by sclerophyllous species. Herbaceous vegetation is sparse (Laessle 1942). Sand pine scrub differs from sandhill forests in appearance, species composition, and site location (Monk 1965). Kurz (1942), in comparing scrub and sandhill vegetation, stated that the scrub had a preponderance of evergreen trees and shrubs, a sparseness of herbs, an abundance of saw palmetto, and white or almost white surface sands and appeared as an impenetrable thicket. Scrub forests are mostly restricted to well-drained sand deposits that have been strongly washed and sorted by wind and wave action (Monk 1968).

The exact origin of scrub vegetation and the relationship between sandhill and scrub vegetation are unclear (Kurz 1942, Laessle 1942). As with the sandhills, scrub is fire-maintained; however, fires are infrequent because of the sparse herbaceous layer. Following a fire, the shrubs sprout quickly from their root crowns and the sand pine reseeds readily, soon restoring the forest to its normal appearance. In the absence of fire, sand pine scrub proceeds toward the xeric hammock forest (Monk 1968).

Characteristic of the scrub are:

- Woody Species

Sand pine	*Pinus clausa*
Myrtle oak	*Quercus myrtifolia*
Chapmans oak	*Quercus chapmanii*
Live oak	*Quercus virginiana*

Saw palmetto	*Serenoa repens*
Wild olive	*Osmanthus americana*
Staggerbush	*Lyonia fruticosa*
Rusty lyonia	*Lyonia ferruginea*
Fetterbush	*Lyonia lucida*
Scrub holly	*Ilex caroliniana*
Scrub palmetto	*Sabal etonia*
Siltbay	*Persea humilis*
Garberia	*Garberia fruticosa*
Rosemary	*Ceratiola ericoides*
Shiny blueberry	*Vaccinium myrsinites*
Greenbrier	*Smilax* spp.
Wax myrtle	*Myrica cerifera*

- Herbaceous Species

Beak-rush	*Rhynchospora megalocarpa*
Florida beard-grass	*Andropogon floridanus*
Panic grass	*Panicum patentifolium*
Fern	*Selaginella* spp.
Prairie clover	*Petalostemon feayi*
Prickly pear	*Opuntia* sp.

3. Wetlands

a. Forested Wetland

Wetlands, as defined by the USGS and considered in this study, are areas in which the water table is at, near, or above the land surface for a significant part of most years (Anderson et al 1976). They are considered to be forested wetlands if they are dominated by woody vegetation. The three forested wetland types in the study area are: swamps, which include mixed hardwoods, cypress, and mangrove; bay forest or bayhead; and brushland or swamp thicket.

1) Swamps

A swamp is a woody community in an area where the soil is saturated or covered with surface water for 1 or more months of the growing season (Penfound 1952).

a) Mixed Hardwoods

This swamp forest class is difficult to distinguish from low or hydric hammocks and is often termed a hydric hammock. The transition from a mixed hardwood swamp to a hydric hammock is often broad and ill-defined where elevation changes are gradual (Laessle 1942). Extensive areas intermediate between the two associations occur where periodic flooding is of brief duration. Monk (1965) concluded that hornbeam (*Carpinus caroliniana*) was a good indicator of the boundary between mixed hardwood swamps and a hammock community.

The mixed hardwood swamp occurs in shallow freshwater areas that are inundated for only short periods during the growing season (Penfound 1952). Monk (1966) found that maximum flooding in the mixed swamps of northcentral Florida averaged 48 centimeters (19 inches) and ranged from 25 to 83 centimeters (10 to 35 inches).

Soils in mixed hardwood swamps, as in other swamplands, are poorly drained, have a high moisture content and an organic-matter content that is higher than that of most upland soils, and usually are more fertile (Harlow 1959). These swamps usually occur along flowing waters such as creeks, rivers, sloughs, and irregularly flooded basins. They generally form elongated stands that follow low drainage areas (Teas 1976).

Vegetation, often dense, is dominated primarily by broad-leaved deciduous species (Monk 1968). Tree composition varies considerably from site to site; generally, no site is dominated by any one species. Shrubs, vines, ferns, and epiphytes usually are dense. Herbaceous vegetation is diverse but patchy (Cowell 1974). This hydric association is typically considered climax, although it may be succeeded by hammock communities if drier conditions occur.

Characteristic plants include:

- Woody Species

Bald cypress	*Taxodium distichum*
Red maple	*Acer rubrum*
Water oak	*Quercus nigra*
Laurel oak	*Quercus laurifolia*
Blackgum, tupelo	*Nyssa sylvatica*
Carolina or water ash	*Fraxinus caroliniana*
Water hickory	*Carya aquatica*
Water locust	*Gleditsia aquatica*
Sweet gum	*Liquidambar styraciflua*
Buttonbush	*Cephalanthus occidentalis*
Dahoon holly	*Ilex cassine*
Cabbage palm	*Sabal palmetto*

Wax myrtle	*Myrica cerifera*
Swamp bay	*Persea palustris*
Sweet bay	*Magnolia virginiana*
Southern willow	*Salix caroliniana*
Poison ivy	*Rhus radicans*
Climbing hempweed	*Mikania scandens*
Pepper vine	*Ampelopsis arborea*
Elm	*Ulmus* spp.
Blue-beech, hornbeam	*Carpinus caroliniana*
Southern red cedar	*Juniperus silicicola*
Climbing hydrangea	*Decumaria barbara*
Haw	*Viburnum* spp.
Grape	*Vitis* spp.

- Herbaceous Species

Lizard's tail	*Saururus cernuus*
Ferns	*Osmunda*, *Polypodium*, *Blechnum*, *Thelypteris*, and *Woodwardia* spp.
Pennywort	*Hydrocotyle* spp.
Smartweed	*Polygonum* spp.
Sedge	*Carex* spp.
Panic grass	*Panicum* spp.
Air-plant	*Tillandsia* spp.

b) Cypress

Cypress swamp communities typically occupy deep freshwater habitats containing surface water throughout most or all of the growing season (Penfound 1952). Cypress is found most frequently fringing ponds, sloughs, lagoons, rivers, and lakes and in river floodplains (Monk 1965, 1966). Either bald cypress (*Taxodium distichum*) or pond cypress (*T. ascendens*) dominate cypress swamps, with pond cypress normally occurring on sites having lower pH values (Laessle 1942, Monk 1968). In some areas, bald cypress occurs in pure stands with no associated species except an abundance of epiphytes; in other areas, trees common in the mixed hardwood swamp association are found with the cypress. Monk and Brown (1965) considered the actual boundaries between wetlands supporting cypress stands and pine flatwoods to be indicated by the presence of saw-palmetto and inkberry or gallberry (*Ilex glabra*).

Cypress communities often have a characteristically zoned internal arrangement (Teas 1976): the largest cypress trees generally occupy the centermost, permanently flooded zone where surface water ranges in depth from 0.3 to 1.3 meters (1 to 4 feet) and never dries up except in years of below-normal rainfall; surrounding the pond, in shallower water, is an organic mat zone where there are considerable accumulations of organic debris and mostly large trees and a few smaller ones; trees become pregressively smaller as distance from the centermost zones increases. Between the organic mat zone and the edge of the stand, surface water fluctuates considerably: it may be 0.7 meter (2 feet) deep in the wet summer and generally dry in spring (Monk and Brown 1965). Sapling-size trees generally occur along the stand margin where flooding is infrequent. Cypress trees require a seasonal fluctuation of water levels to below the soil surface if they are to successfully produce viable offspring (Teas 1976).

Cypress communities are considered subclimax. If they become drier through the accumulation of organic materials or the lowering of the water table, they will be succeeded by mixed hardwood swamp or bayhead (Monk 1968).

Plants occurring in cypress swamps include:

- Woody Species

Bald cypress	*Taxodium distichum*
Pond cypress	*Taxodium ascendens*
Carolina or water ash	*Fraxinus caroliniana*
Red maple	*Acer rubrum*
Sweet gum	*Liquidambar styraciflua*
Water hickory	*Carya aquatica*
Hornbeam, blue-beech	*Carpinus caroliniana*
Blackgun, tupelo	*Nyssa sylvatica*
Water locust	*Gleditsia aquatica*
Buttonbush	*Cephalanthus occidentalis*
Willow	*Salix* spp.
Wax myrtle	*Myrica cerifera*
Pines	*Pinus* spp.
Stiff cornel	*Cornus foemina*
Elderberry	*Sambucus simpsonii*
Florida privet	*Forestiera liqustrina*
Sweet bay	*Magnolia virginiana*
Red bay	*Persea borbonia*
Sand-cypress	*Hypericum fasciculatum*

- Herbaceous Species

Ferns	*Osmunda, Woodwardia*
Air-plants	*Tillandsia* spp.
Lizard's tail	*Saururus cernuus*
Smartweed	*Polygonum* spp.
Pennywort	*Hydrocotyle* spp.
Sedge	*Carex* spp.
Redroot	*Lachnanthes caroliniana*

Bladderwort	*Utricularia* spp.
Beak-rush	*Rhynchospora* spp.
Sawgrass	*Cladium jamaicense*
Fire or tall flag, arrowroot	*Thalia geniculata*
Spike-rush	*Eleocharis* spp.
Floating-hearts	*Nymphoides aquaticum*
Panic grass	*Panicum* spp.

c) Mangrove

Mangrove swamps occupy the marine littoral zone where regular (periodic or occasional) tidal flushing occurs. Deep-water mangroves are flooded on every tide (periodic); shallow-water mangroves are regularly flooded, although not on every tide (Teas 1976).

A mangrove swamp has at least one species of the following: red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and white mangrove (*Laguncularia racemosa*). All three species will grow in salt water but apparently grow larger and faster in brackish water (Teas 1976).

These swamps form distinct vegetational zones of arborescent plants with which a few plants other than mangroves are more or less commonly associated (Davis 1940). Vegetation composition varies greatly among sites, and characterization of a "typical" Florida mangrove community is not possible. Generally, an outer zone of red mangroves, sometimes extending far offshore, occurs on soils that are nearly always flooded by even the low tide. In the middle zone, which is on soils that are usually exposed at low tide but generally covered at high tide, black mangroves dominate and a number of saltmarsh plants often occur. An inner transitional zone, which occurs about the usual level of high tide and is seldom flooded by water, is dominated by buttonwood (*Conocarpus erectus*) and marsh/prairie plants that require little or no salt water.

White mangrove usually does not form a distinct community but is an associate of either of the other mangroves (Davis 1940); it is fast-growing and may quickly invade storm-damaged areas and agricultural land that has been abandoned because of salt intrusion. Mangroves have an efficient mode of dispersal and establish easily in littoral areas; once established, they collect sediments and build land (Teas 1976). Other important coastal ecological roles of mangrove swamps include nutrient addition and cycling, maintenance of water clarity, and buffering against wind and high tides.

Common plants found in mangrove swamps include:

- Woody Species

Red mangrove	*Rhizophora mangle*
Black mangrove	*Avicennia germinans*
White mangrove	*Laguncularia racemosa*
Buttonwood	*Conocarpus erectus*

- Woody/Herbaceous Species

Saltwort	*Batis maritima*
Glasswort	*Salicornia virginica*

- Herbaceous Species

Salt grass	*Distichlis spicata*
Cordgrass	*Spartina* spp.
Fringe rush	*Fimbristylis* spp.
Rush	*Juncus* spp.
Leather fern	*Acrostichum aureum*
Coin vine	*Dalbergia ecastophyllum*

2) Bay Forest or Bayhead

This forest association is dominated by broad-leaf evergreen trees growing on acidic water-saturated soils high in organic matter and subjected to seasonal flooding (Monk 1968). Monk (1966) found the depth of maximum flooding in northcentral Florida bayheads to average 15 centimeters (6 inches) and range from 0 to 36 centimeters (0 to 14 inches). Bayheads may develop from bays, marshes, or swamps and are found characteristically in depressions in the pine flatwoods region. Compared with mixed hardwood swamps, bayhead habitats occupy sites that are usually lower in calcium, magnesium, calcium/magnesium, calcium/potassium, pH, and depth of maximum flooding (Monk 1966); generally they are more sterile and more acid and are not flooded as deeply as is the mixed swamp habitat. Also, evergreen species tend to be more important in bayheads than in mixed swamps. With sufficient accumulation of peat, bayheads will succeed to hardwood hammocks (Davis 1943).

Bayheads are dominated by several species of bay including sweet bay (*Magnolia virginiana*), swamp bay (*Percea palustris*), and loblolly bay (*Gordonia* *lasianthus*). The undergrowth is often shrubby. Because of the densely shaded interior, herbaceous vegetation is sparse and many bayheads are essentially a 1-layered association. Plants found in bay forests include:

- Woody Species

Sweet bay	*Magnolia virginiana*
Swamp bay	*Persea palustris*
Loblolly bay	*Gordonia*
Sweet gum	*Liquidambar styraciflua*
Blackgum, tupelo	*Nyssa sylvatica*
Red maple	*Acer rubrum*
Water oak	*Quercus nigra*
Slash pine	*Pinus elliottii*
Bald cypress	*Taxodium distichum*
Wax myrtle	*Myrica cerifera*
Grape	*Vitis* spp.
Greenbrier	*Smilax* spp.
Dahoon holly	*Ilex cassine*
Groundsel-tree	*Baccharis halimifolia*
Fetterbush	*Lyonia lucida*

- Herbaceous Species

Sedge	*Carex* spp.
Ferns	*Woodwardia, Osmunda, Dryopteris, Blechnum*
Tassel white	*Itea virginica*

3) Brushland

Wetlands dominated by shrubs or low trees are often termed swamp thickets (Davis 1943). Herbaceous plants in swamp thickets are those found typically in cypress and mixed hardwood swamps. Thicket swamps either border the large tree swamps or, in some marsh areas, grow where soils, which usually are peaty or mucky, have been cleared, cultivated, and then abandoned. This woody association will gradually be succeeded by a large tree swamp if hydrological conditions remain favorable and there is no further disturbance.

Woody plant species often occurring in swamp thickets are:

Elderberry	*Sambucus simpsonii*
Buttonbush	*Cephalanthus occidentalis*
Southern willow	*Salix caroliniana*
Groundsel-tree	*Baccharis halimifolia*
Primrose willow	*Ludwigia* spp.

b. Nonforested Wetland

Nonforested wetlands are dominated by wetland herbaceous vegetation (Anderson et al 1976). The nonforested wetland classes in the study area are wet prairie, deep freshwater marsh, salt marsh, and artificially created marsh.

1) Wet Prairie

Wet prairies support herbaceous communities on low, seasonally wet or flooded soils (Davis 1943, Frye 1954, Teas 1976). Usually, surface water is present during only a part of the growing season (Penfound 1952).

Often, wet prairies are considered shallow, freshwater marshes; any distinction is arbitrary. Shallow marshes are flooded during the wet season to depths ranging from several centimeters (several inches) to a maximum of 76 centimeters (2.5 feet) and are dry during the dry season (Penfound 1952, Goodrick and Milleson 1974).

Wet prairies comprise grasses, sedges, rushes, numerous other herbs, and some shrubs, with species composition varying widely from site to site. A characteristic community is dominated by one graminoid species (i.e., grass, sedge, rush) and numerous other emergent species of lesser importance.

Wet prairies may occur on sand or muck soils. In the pine flatwoods region, wet prairies are transitional areas between deeper water marshes and flatwoods. Typically, these are grassy meadows with no shrubs or with scattered saw palmetto and an occasional stunted slash pine. The amount of ground cover varies, depending on water depth and species composition, and the vegetation may be zoned or uniformly distributed. Plant zonation from edge to interior is evident in many of the marshes in response to progressively deeper water levels during the growing season. Inside the wet prairie, a deepwater marsh and even a pond may be present. Wet prairies are normally succeeded by either a cypress or a mixed hardwood swamp (Monk 1968).

Most common to wet prairie are:

- Woody Species

Saw palmetto	*Serenoa repens*
Sand cypress	*Hypericum fasciculatum*
Corkwood	*Stillingia aquatica*

- Herbaceous Species

Wiregrass	*Aristida* spp.
White top	*Dichromena* spp.
Broomsedge, beard-grass	*Andropogon* spp.
Beak-rush	*Rhynchospora* spp.
Panic grass	*Panicum* spp.
Maidencane	*Panicum hemitomon*
Lovegrass	*Eragrostis elliottii*
Cattail	*Typha* spp.
Spike rush	*Eleocharis* spp.
Bulrush	*Scirpus* spp.
Fringe rush	*Fimbristylis* spp.
Sawgrass	*Cladium jamaicense*
Pickerel-weed	*Pontederia cordata*
Arrowhead	*Sagittaria* spp.
Bladderwort	*Utricularia* spp.
Yellow-eyed grass	*Xyris* spp.
Pennywort	*Hydrocotyle* spp.
Meadow beauty	*Rhexia* spp.
Coinwort	*Centella asiatica*
Rush	*Juncus* spp.
Sedge	*Carex* spp.
Galingale	*Cyperus* spp.
Pipewort	*Eriocaulon* spp.
Yellow pond lily, spatterdock	*Nuphar luteum*
Cordgrass	*Spartina* spp.

2) Deep Freshwater Marsh

This class is defined as a wetland in which the soil is covered by water throughout most or all of the growing season (Penfound 1952). Many of the sites may be considered temporary ponds.

Deep freshwater marsh communities, characterized by either emergent or floating-leaf aquatic plants (Teas 1976), develop along the margins of ponds and lakes, in open marshlands, and in open sloughs. In Florida, inundation is generally permanent, with annual fluctuation in water depth varying from 0.1 to 2.5 meters (4 inches to 8 feet). Floating-leafed species are more common in water depth averaging 1.0 to 2.5 meters (3 to 8 feet) (Teas 1976); cattail (*Typha* spp.) marshes develop where the water depth averages less than 1 meter (3 feet) and sawgrass (*Cladium jamaicense*) marshes where the depth of inundation is even less. Deep marshes will succeed to shallow marshes if conditions become drier.

Many of the plants of shallow marshes occur also in deep marshes. Particularly characteristic of deep marshes are:

- Woody Species

Buttonbush	*Cephalanthus occidentalis*

- Herbaceous Species

Cattail	*Typha* spp.
Sawgrass	*Cladium jamaicense*
Lotus	*Nelumbo lutea*
Purple-flowered (blue) water lily	*Nymphaea elegans*
White water lily	*Nymphaea odorata*
Yellow pond lily, spatterdock	*Nuphar luteum*
Water shield	*Brasenia schrebers*
Floating hearts	*Nymphoides aquatica*
Pickerel-weed	*Pontederia cordata*
Arrowhead	*Sagittaria* spp.
Fire or tall flag, arrowroot	*Thalia geniculata*
Spike rush	*Eleocharis* spp.
Maidencane	*Panicum hemitomon*

3) Salt Marsh

Salt marshes are plant communities of the intertidal zone. They develop along coasts of low energy and gradual slope (Humm 1973). If they are regularly flooded by tides, they are considered to be deep marshes; if they are occasionally flooded, they are considered to be shallow marshes (Teas 1976).

The dominant plants in salt marshes exhibit a distinctive zonation, which is controlled primarily by the periodic rise and fall of the tide. Species distribution is determined by a combination of factors including substrate composition, elevation, pH, salinity, and the frequency and duration of tidal inundation. Saltmarsh vegetation consists predominantly of three grass species, one rush species, and a few species of succulent dicots. Smooth, or saltmarsh, cordgrass (*Spartina alterniflora*) characterizes the seaward zone. Black rush (*Juncus roemerianus*) occupies slightly higher ground, often forming an almost pure stand; *Juncus* typically exhibits the greatest areal extent of any saltmarsh plant. A third zone, which is above the high tide line, is characterized either by saltmeadow cordgrass (*Spartina patens*) or salt grass (*Distichilis spicata*). The successional progress of salt marshes, if it exists, is certainly affected by the water regime, but evidence of succession is lacking (Humm 1973).

Herbaceous plants characteristic of salt marshes include:

Smooth cordgrass	*Spartina altermiflora*
Saltmeadow cordgrass	*Spartina patens*
Black rush	*Juncus roemerianus*
Fringe rush	*Fimbristylis castanea*
Salt grass	*Distichilis spicata*
Saltwort	*Batis maritima*
Glasswort	*Salicornia* spp.
Sea purslane	*Sesurium portulacastrum*
Amaranth	*Amaranthus* spp.
Sea-blite	*Suaeda linearis*
Salt weed	*Philoxerus vermicularis*
Key grass	*Monanthochloe littoralis*

4) Artificially Created Marsh

In Florida, artificial marshes often develop from the settling ponds used in phosphate processing. Vegetation in artificially created marshes is similar to that present in natural marshes. Cattail is an early colonizer. Because the artificial water source is removed when the settling ponds reach capacity, these wetlands succeed more rapidly to a mesic community than do natural wetlands. Southern willow (*Salix caroliniana*) is one of the first woody invaders in these areas.

4. Unique Communities

A unique community may be defined as one which is atypical and limited in distribution to a particular area; i.e., it is not generally present elsewhere and is of particular interest because of distinctive characteristics (Lowman 1975). Distinctive characteristics that may be considered include aesthetic value, high biological productivity and diversity, fragility, unaltered or unspoiled condition, presence of endangered or threatened species, and historic value (Florida Department of Administration 1975). Florida, with its wealth of natural resources, is receiving increasing attention from a variety of sources as many of its natural resources come under increased environmental stress.

The Florida Committee on Rare and Endangered Plants and Animals, a nongovernmental organization, is preparing a discussion on critical Florida habitats (Florida Committee on Rare and Endangered Plants and Animals 1976). Also, rare and unique natural resources have been addressed by Florida's Department of Administration (Florida Department of Administration 1975), but none of the 31 representative areas listed are within the study area, although a map included in the report identifies Telegraph Swamp, which is in southeastern Charlotte County. Public acquisition, purchase of easements or partial rights, regulation, and public awareness/educational programs are among the means used to protect these natural areas.

The Florida Department of Natural Resources has instituted the Environmentally Endangered Lands Program to conserve and protect these lands (Florida Department of Natural Resources 1975). One criterion of an environmentally endangered land is the presence of flora, fauna, or geologic resources that are both characteristic of the original domain of Florida and unique to, or otherwise scarce within, the region or larger geographical areas. Within the DNR, the Division of Recreation and Parks has begun a registration program that will include a certification and description of unique biological features (Florida Department of Natural Resources 1975). The Lake Wales Ridge (Figure 5.2) has been identified as a region with distinctive plant and animal communities. The major plant community occurring in this area that may be considered unique is the sand pine scrub. Since much of the sandhill community of longleaf pine/turkey oak association has been converted to several forms of agricultural production, the remaining parcels are considered highly endangered and undisturbed sandhills may be approaching a unique status.

The Florida Game and Fresh Water Fish Commission has evaluated natural communities occurring in the watersheds of the study area also, giving them priority ranking and indicating those most deserving of protection (Florida Environmental Land Management Study Committee 1973). First-priority communities include sand pine scrub, wet prairie, hardwood hammock, and cypress swamp. Dry prairie and swamp forest have either primary or secondary priority rankings, depending on the watershed considered; freshwater marshes and sandhills have secondary rankings, regardless of watershed.

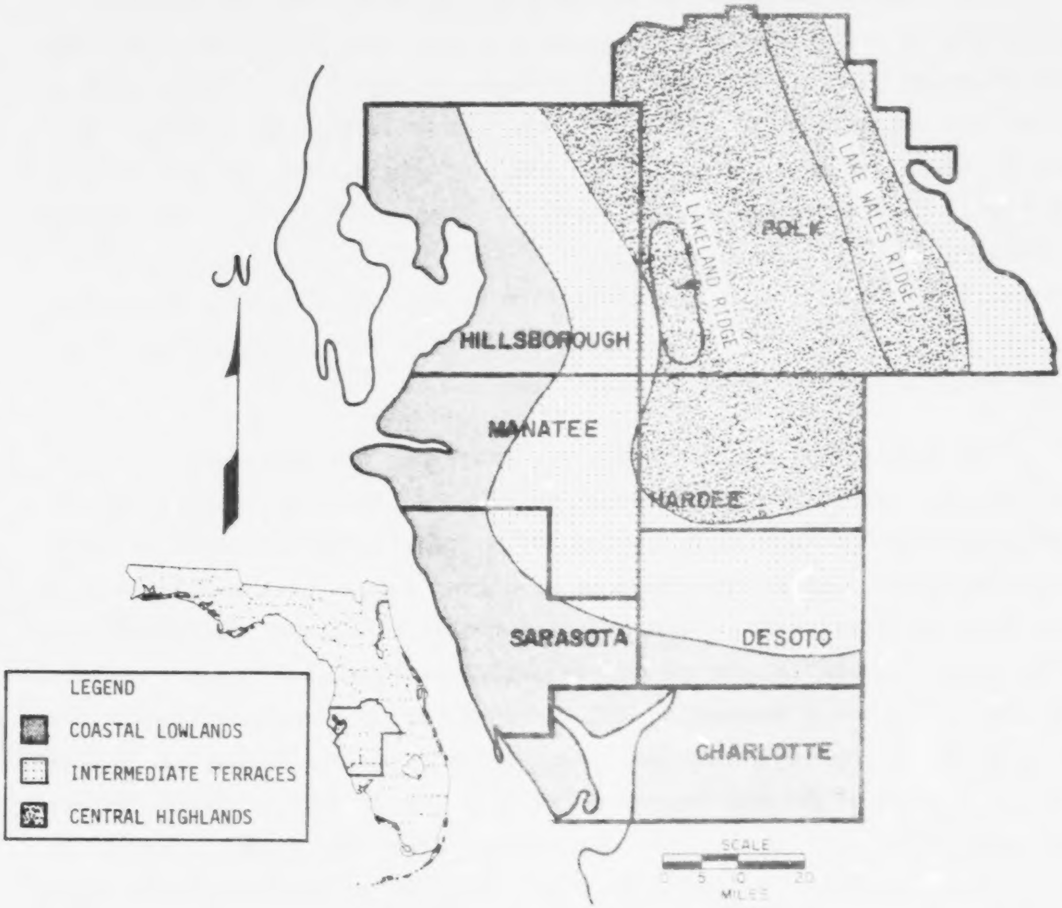

N
HILLSBOROUGH
POLK
LAKELAND RIDGE
LAKE WALES RIDGE
MANATEE
HARDEE
SARASOTA
DESOTO
CHARLOTTE
LEGEND
COASTAL LOWLANDS
INTERMEDIATE TERRACES
CENTRAL HIGHLANDS
SCALE
0 5 10 20
MILES

Figure 5.2. Landforms of Central Florida (Boyles 1966)

Endangered and threatened plants, which are important in the consideration of unique communities, recently have received attention as well. Many plant (and faunal) species have been designated endangered or threatened or have been proposed as such by various governmental agencies or citizen groups. The endangered and threatened species given official consideration by the state of Florida are those listed by the U.S. Department of the Interior and the Florida Fresh Water Game and Fish Commission. According to the law that promulgated the federal list (U.S. Public Law 93-205; 87 Stat. 884), endangered species are those in danger of extinction throughout all or a significant part of their ranges whereas threatened species are those likely to become endangered within the forseeable future throughout all of a significant part of their ranges. The Florida Game and Fresh Water Fish Commission follows similar guidelines in designating threatened and endangered species and subspecies in the state.

Investigating "priority" species in Florida is the Florida Committee on Rare and Endangered Plants and Animals (FCREPA); this group of authorities on various plant and animal groups, acting on behalf of the Florida Audubon Society and the Florida Defenders of the Environment, has prepared a preliminary inventory of those species and presented pertinent range, habitat, biology, and status data on many of them (FCREPA 1976). Based on an assessment of current status in Florida and possible status as development continues in the state, species have been categorized as endangered, threatened, of special concern undetermined status, rare, recently extirpated (exterminated from an area), or recently extinct. The first two categories comprise species meeting criteria similar to those with the same designations on official lists. Species of "special concern" may not be endangered at present, but their habitats may be diminishing, so the habitats are considered of the highest priority for preservation. Some species possibly are threatened or endangered, but supportive data are insufficient to warrant such designations, so they are designated "status undetermined." The status of species in the latter three categories is implicit. In preparing both the inventory of priority species and the discussion of critical habitat (mentioned previously) in Florida, FCREPA hopes to provide data pertinent to land use planning in the state.

In the proposed federal list are 84 endangered plant species and 128 threatened plant species that occur in Florida (Federal Register 1975b, Smithsonian Institution 1975). FCREPA lists 41 plants as endangered, 106 as threatened, and 2 as species of special concern. Of the 149 species on FCREPA's list, 27 are on the federal list as endangered and 25 are on the federal list as threatened. FCREPA's forthcoming definitive inventory will include accounts of all listed plant species; the preliminary inventory presents accounts for the 41 endangered species.

Four species considered by both FCREPA and USDI to be endangered occur in the study area: Highlands scrub hypericum (*Hypericum cumulicola*), Lewton's polygala (*Polygala lewtonii*), scrub plum (*Prunus geniculata*), and pygmy fringe-tree (*Chionanthus pygmaeus*). These species are restricted to the white sands of the sand pine scrub association of the Lake Wales Ridge in eastern Polk County. A fifth species considered only by FCREPA to be endangered is auricled spleenwort (*Asplenium auritum*), a fern occurring on the inclined trunks of large trees (usually live oak) in the study area along the Hillsborough River in Pasco and Hillsborough counties.

Certain plants in Florida, although not presently endangered or threatened, are protected from exploitation or willful destruction; in 1965, the state of Florida enacted a rare plant law (Florida Law, Chapter 65-426, Section 865.06) making it unlawful to willfully pick, pull up, tear up, dig up, cut, break, injure, destroy, or transport or sell any of several plant species. These protected plants include most bromeliads, all native orchids, most native ferns, all native palms except cabbage palm, as well as more than 30 other species.

Exotic or non-native plants also contribute to the uniqueness of a community or habitat. Several exotics have become established in the study area, creating extensive nuisance conditions; it is generally conceded, however, that exotic invasion is most critical in the Everglades of south Florida. Apparently, the most important terrestrial exotic plants are Brazilian or Florida holly (*Schinus terebinthifolius*), Australian pine or Casuarina (*Casuarina equisetifolia* and *C. glauca*), and Melaleuca or punk tree (*Melaleuca quinquenervia*) (LaHart 1977). Brazilian pepper is most likely to invade land that has already been disturbed by development (e.g., abandoned agricultural land, canal banks, and roadsides). In drier areas, it grows in dense stands, crowding out native vegetation; its sap is an irritant, causing a rash on many people. Australian pine, which was introduced for wind breaks and erosion control, has excluded native vegetation along beach areas and may form dense barricades, eliminating coastal habitat. Melaleuca was introduced into south Florida's extensive wetlands as an ornamental and wood-producing tree; as a result, many wetlands are rapidly becoming Melaleuca monocultures. Control methods are being researched extensively. Contributing factors to the establishment and spread of Melaleuca and other exotics include modifications of the natural wet and dry cycle, changes in land use, increased human population, and changes in the frequency and severity of fires.

C. ANIMALS

1. Vertebrates

a. Species and Distribution

Animal distribution in central Florida is greatly influenced by three landforms — the Central Highlands, the Coastal Lowlands, and the Intermediate Terraces (Figure 5.2) — and their associated habitats. Each landform often acts as a barrier that restricts dispersal, particularly of species with narrow habitat requirements. The landforms, then, can be considered zoogeographic zones.

The Central Highlands, with its higher elevations, comprises diverse habitats. Many animals, within their central Florida range, are restricted almost exclusively to the zone. Vertebrates closely associated with the zone include the blue-tailed mole skink, Scrub Jay, and Florida mouse. Within the zone, the Lakeland and Lake Wales ridges contain unique habitat.

The Coastal Lowlands, although not as vegetationally diverse as the uplands, comprises a variety of terrestrial habitats associated with marine and estuarine habitats. Many species inhabiting this region (e.g., Snowy Plover and Mangrove Cuckoo) are completely associated with a coastal environment, infrequently venturing outside its influence.

The Intermediate Terraces, separating the uplands and lowlands, is in part a transition zone in which fauna is a mixture of species from the other two zones.

More than 500 species and subspecies of vertebrates (excluding fishes) are represented or have been represented in the recent past in the 7-county study area (Table 5.2). Many, as pointed out in the table, are of special interest or concern by virtue of economic or ecological importance (see section on ecologically significant species). The table also indicates applicable population status designations by the U.S. Department of Interior (USDI), the Florida Game and Fresh Water Fish Commission (FGFWFC), and the

Table 5.2. Amphibians, Reptiles, Birds, and Mammals of Study Area (Page 1 of 8)

AMPHIBIANS		
Common Name	Scientific Name	Special Status
Penisula Newt	*Notophthalmus viridescens*	
Dwarf Siren	*Pseudobranchus striatus*	Ecologically significant*
Lesser Siren	*Siren intermedia intermedia*	Ecologically significant
Greater Siren	*Siren lacertina*	
Two-toed Amphiuma	*Amphiuma means*	
Southern Dusky Salamander	*Desmognathus auriculatus*	Ecologically significant
Dwarf Salamander	*Eurycea quadridigitata*	Ecologically significant
Slimy Salamander	*Plethodon glutinosus*	Ecologically significant
Eastern Spadefoot Toad	*Scaphiopus holbrooki*	Ecologically significant
Oak Toad	*Bufo quercicus*	
Southern Toad	*Bufo terrestris*	
Giant Toad	*Bufo marinus*	Ecologically significant
Eastern Narrow-mouthed Toad	*Gastrophryne carolinensis*	
Southern Leopard Frog	*Rana utricularia*	
Florida Gopher Frog	*Rana areolata*	Threatened (FGFWFC, FCREPA)**
Bronze Frog	*Rana clamitans*	Ecologically significant
Bullfrog	*Rana catesbeiana*	Ecologically significant
Pig Frog	*Rana grylio*	Ecologically significant
Greenhouse Frog	*Eleutherodactylus planirostris*	
Southern Cricket Frog	*Acris gryllus*	
Green Treefrog	*Hyla cinerea*	
Cuban Treefrog	*Hyla septentrionalis*	Ecologically significant
Pine Woods Treefrog	*Hyla femoralis*	
Barking Treefrog	*Hyla gratiosa*	
Squirrel Treefrog	*Hyla squirella*	
Little Grass Frog	*Hyla ocularis*	
Southern Chorus Frog	*Pseudacris nigrita*	
Ornate Chorus Frog	*Pseudacris ornata*	Ecologically significant
REPTILES		
American Alligator	*Alligator mississippiensis*	Threatened (USDI, FGFWFC), special concern (FCREPA)
Snapping Turtle	*Chelydra serpentina*	
Striped Mud Turtle	*Kinosternon bauri*	
Mud Turtle	*Kinosternon subrubrum*	
Stinkpot Turtle	*Sternotherus odoratus*	
Eastern Box Turtle	*Terrapene carolina*	Ecologically significant
Diamondback Terrapin	*Malaclemys terrapin*	Ecologically significant
Suwannee Cooter	*Chrysemys concinna suwanniensis*	Threatened (FGFWFC, FCREPA)
Peninsular Cooter	*Chrysemys floridana*	
Florida Red-bellied Turtle	*Chrysemys nelsoni*	
Chicken Turtle	*Deirochelys reticularia*	
Gopher Tortoise	*Gopherus polyphemus*	Threatened (FGFWFC, FCREPA)
Florida Softshell Turtle	*Trionyx ferox*	Economically significant
Atlantic Leatherback Turtle	*Dermochelys coriacea*	Endangered (USDI), rare (FCREPA)
Atlantic Loggerhead Turtle	*Caretta caretta caretta*	Threatened (FGFWFC, FCREPA)
Atlantic Ridley Turtle	*Lepidochelys kempi*	Endangered (USDI, FGFWFC, FCREPA)
Atlantic Green Turtle	*Chelonia mydas*	Endangered (FGFWFC)

*Ecologically significant: species is restricted to a certain habitat type or local geographic area or is an ecological indicator of environmental change or is an introduced species that has become established or reaches one of the boundaries of its distribution range

**FGFWFC - Florida Game and Fresh Water Fish Commission
FCREPA - Florida Committee on Rare and Endangered Plants and Animals

Table 5.2. (Page 2 of 8)

REPTILES (CONTD)		
Common Name	Scientific Name	Special Status
Worm Lizard	*Rhineura floridana*	Ecologically significant
Gecko	*Gekko Gecko*	
Mediterranean Gecko	*Hemidactylus turcicus*	
Green Anole	*Anolis carolinensis*	Ecologically significant
Brown Anole	*Anolis sagrei*	
Texas Horned Lizard	*Phrynosoma cornutum*	
Fence Lizard	*Sceloporus undulatus*	Ecologically significant
Florida Scrub Lizard	*Sceloporus woodi*	Rare (FCREPA)
Six-lined Racerunner	*Cnemidophorus sexlineatus*	
Southeastern Five-lined Skink	*Eumeces inexpectatus*	
Blue-tailed Mole Skink	*Eumeces egregius lividus*	Threatened (FGFWFC, FCREPA)
Peninsula Mole Skink	*Eumeces egregius onocrepis*	
Broad-headed Skink	*Eumeces laticeps*	Ecologically significant
Sand Skink	*Neoseps reynoldsi*	Threatened (FGFWFC, FCREPA)
Ground Skink	*Lygosoma laterale*	
Slender Glass Lizard	*Ophisaurus attenuatus*	
Island Glass Lizard	*Ophisaurus compressus*	
Eastern Glass Lizard	*Ophisaurus ventralis*	
Scarlet Snake	*Cemophora coccinea*	
Black Racer Snake	*Coluber constrictor*	
Eastern Ringneck Snake	*Diadophis punctatus*	
Eastern Indigo Snake‡	*Drymarchon corais couperi*	Threatened (FGFWFC); special concern (FCREPA)
Corn Snake	*Elaphe guttata*	
Yellow Rat Snake	*Elaphe obsoleta*	
Mud Snake	*Farancia abacura*	
Rainbow Snake	*Farancia erytrogramma*	
Eastern Hognose Snake	*Heterodon platyrhinos*	
Southern Hognose Snake	*Heterodon simus*	Ecologically significant
Scarlet Kingsnake	*Lampropeltis triangulum*	
Florida Kingsnake	*Lampropeltis getulus*	
Striped Swamp Snake	*Liodytes alleni*	Ecologically significant
Eastern Coachwhip Snake	*Masticophis flagellum*	
Green Water Snake	*Natrix cyclopion*	
Florida Water Snake	*Natrix fasciata pictiventris*	Ecologically significant
Mangrove Water Snake	*Natrix fasciata compressicauda*	Ecologically significant
Brown Water Snake	*Natrix taxispilota*	
Rough Green Snake	*Opheodrys aestivus*	
Pine Snake	*Pituophis melanoleucus*	
Pine Woods Snake	*Rhadinaea flavilata*	Ecologically significant
Florida Swamp Snake	*Seminatrix pygaea*	Ecologically significant
Short-tailed Snake	*Stilosoma extenuatum*	Endangered (FGFWFC, FCREPA)
Florida Brown Snake	*Storeria dekayi*	
Red-bellied Snake	*Storeria occipitomaculata*	Ecologically significant
Florida Crowned Snake	*Tantilla relicta*	Ecologically significant
Ribbon Snake	*Thamnophis sauritus*	
Eastern Garter Snake	*Thamnophis sirtalis*	
Smooth Earth Snake	*Virginia valeriae*	Ecologically significant
Eastern Coral Snake	*Micrurus fulvius*	
Cottonmouth Moccasin	*Agkistrodon piscivorus*	
Eastern Diamondback Rattlesnake	*Crotalus adamanteus*	
Pigmy Rattlesnake	*Sistrurus miliarius*	Ecologically significant

‡ USDI designated threatened March 3, 1978.

Table 5.2. (Page 3 of 8)

BIRDS		
Common Name	Scientific Name	Special Status
Common Loon	*Gavia immer*	
Arctic Loon	*Gavia arctica*	
Red-throated Loon	*Gavia stellata*	
Red-necked Grebe	*Podiceps grisegena*	Blue-listed
Horned Grebe	*Podiceps auritus*	
Eared Grebe	*Podiceps nigricollis*	
Western Grebe	*Aechmophorus occidentalis*	Blue-listed
Pied-billed Grebe	*Podilymbus podiceps*	Ecologically Significant
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	
Wilson's Storm-Petrel	*Oceanites oceanicus*	
White Pelican	*Pelecanus erythrorhynchos*	Blue-listed
Brown Pelican	*Pelecanus occidentalis*	Threatened (USDI, FGFWFC, FCREPA)
Blue-faced Booby	*Sula dactylatra*	
Brown Booby	*Sula leucogaster*	
Great Cormorant	*Phalacrocorax carbo*	
Double-crested Cormorant	*Phalacrocorax auritus*	Blue-listed
Anhinga	*Anhinga anhinga*	
Magnificent Frigatebird	*Fregata magnificens rothschildi*	Threatened (FGFWFC, FCREPA)
Great Blue Heron	*Ardea herodias*	Ecologically significant
(Great White Heron)		Threatened (FGFWFC); special concern (FCREPA)
Green Heron	*Butorides striatus*	Ecologically significant
Little Blue Heron	*Florida caerulea*	Special concern (FCREPA)
Cattle Egret	*Bubulcus ibis*	Ecologically significant
Reddish Egret	*Dichromanassa rufescens*	Blue-listed; rare (FCREPA)
Great Egret	*Casmerodius albus*	Special concern (FCREPA)
Snowy Egret	*Egretta thula*	Special concern (FCREPA)
Louisiana Heron	*Hydranassa tricolor*	Special concern (FCREPA)
Black-crowned Night Heron	*Nycticorax nycticorax*	Blue-listed; special concern (FCREPA)
Yellow-crowned Night Heron	*Nyctanassa violacea*	Special concern (FCREPA)
Least Bittern	*Ixobrychus exilis*	Special concern (FCREPA)
American Bittern	*Botaurus lentiginosus*	Blue-listed
Wood Stork	*Mycteria americana*	Endangered (FGFWFC, FCREPA)
Glossy Ibis	*Plegadis falcinellus*	Ecologically significant
White Ibis	*Eudocimus albus*	Special concern (FCREPA)
Scarlet Ibis	*Eudocimus ruber*	Blue-listed
Roseate Spoonbill	*Ajaia ajaja*	Threatened (FGFWFC); rare (FCREPA)
American Flamingo	*Phoenicopterus ruber*	Blue-listed
Whistling Swan	*Olor columbianus*	
Canada Goose	*Branta canadensis*	Game species
Brant	*Branta bernicla*	Game species
Snow Goose	*Chen caerulescens*	Game species
Fulvous Whistling-Duck	*Dendrocygna bicolor*	Blue-listed, game species
Ruddy Sheld-Duck	*Tadorna ferruginea*	Game species
Mallard	*Anas platyrhynchos*	Game species
Black Duck	*Anas rubripes*	Game species
Mottled Duck	*Anas fulvigula*	Game species
Gadwall	*Anas strepera*	Game species
Pintail	*Anas acuta*	Game species
Cinnamon Teal	*Anas cyanoptera*	Game species
Green-winged Teal	*Anas crecca*	Game species
Blue-winged Teal	*Anas discors*	Game species
European Wigeon	*Anas penelope*	Game species
American Wigeon	*Anas americana*	Game species
Northern Shoveler	*Anas clypeata*	Game species
Wood Duck	*Aix sponsa*	Game species
Redhead	*Aythya americana*	Game species
Ring-necked Duck	*Aythya collaris*	Game species
Canvasback	*Aythya valisineria*	Blue-listed, game species
Greater Scaup	*Aythya marila*	Game species
Lesser Scaup	*Aythya affinis*	Game species
Common Goldeneye	*Bucephala clangula*	Game species
Bufflehead	*Bucephala albeola*	Game species
Oldsquaw	*Clangula hyemalis*	Game species
Common Eider	*Somateria mollissima*	Game species
White-winged Scoter	*Melanitta deglandi*	Game species
Surf Scoter	*Melanitta perspicillata*	Game species
Black Scoter	*Melanitta nigra*	Game species
Ruddy Duck	*Oxyura jamaicensis*	Game species
Masked Duck	*Oxyura dominica*	Game species
Hooded Merganser	*Lophodytes cucullatus*	Game species
Common Merganser	*Mergus merganser*	Game species
Red-breasted Merganser	*Mergus serrator*	Game species
Turkey Vulture	*Cathartes aura*	Ecologically significant
Black Vulture	*Coragyps atratus*	Ecologically significant

Table 5.2. (Page 4 of 8)

BIRDS (CONTD)		
Common Name	Scientific Name	Special Status
White-tailed Kite	*Elanus leucurus majusculus*	Rare (FCREPA)
Swallow-tailed Kite	*Elanoides forficatus*	Ecologically significant
Mississippi Kite	*Ictinia mississippiensis*	Ecologically significant
(Florida) Everglade Kite	*Rostrhamus sociabilis plumbeus*	Endangered (USDI, FGFWFC, FCREPA)
Sharp-shinned Hawk	*Accipiter striatus*	Blue-listed; ecologically significant
Cooper's Hawk	*Accipiter cooperii*	Blue-listed; special concern (FCREPA)
Red-tailed Hawk	*Buteo jamaicensis*	Ecologically significant
Red-shouldered Hawk	*Buteo lineatus*	Blue-listed; ecologically significant
Broad-winged Hawk	*Buteo platypterus*	Ecologically significant
Swainson's Hawk	*Buteo swainsoni*	Blue-listed; ecologically significant
Short-tailed Hawk	*Buteo brachyurus*	Threatened (FGFWPC); rare (FCREPA)
Rough-legged Hawk	*Buteo lagopus*	Ecologically significant
Golden Eagle	*Aquila chrysaetos*	Ecologically significant
Bald Eagle	*Haliaeetus leucocephalus*	Endangered (USDI); threatened (FGFWFC, FCREPA)
Marsh Hawk	*Circus cyaneus*	Blue-listed; ecologically significant
Osprey	*Pandion haliaetus*	Blue-listed; threatened (FGFWFC, FCREPA)
Caracara	*Caracara cheriway*	Blue-listed; threatened (FGFWFC, FCREPA)
Peregrine Falcon	*Falco peregrinus*	Endangered (USDI, FGFWPC, FCREPA)
Merlin	*Falco columbarius*	Blue-listed; undetermined (FCREPA)
American Kestrel	*Falco sparverius*	Blue-listed; ecologically significant
(Southeastern) American Kestrel	*Falco sparverius paulus*	Threatened (FGFWFC, FCREPA)
Bobwhite	*Colinus virginianus*	Game species
Chukar	*Alectoris chukar*	
Black Frankolin	*Francolinus francolinus asiae*	
Turkey	*Meleagris gallopavo*	Game species
(Greater) Sandhill Crane	*Grus canadensis tabida*	
(Florida) Sandhill Crane	*Grus canadensis pratensis*	Threatened (FGFWFC, FCREPA)
African Crowned Crane	*Balearica tavonina*	
Limpkin	*Aramus guarauna*	Ecologically significant
King Rail	*Rallus elegans*	Blue-listed; game species
Clapper Rail	*Rallus longirostris*	Game species
(Florida) Clapper Rail	*Rallus longirostris scottii*	Undetermined (FCREPA)
Virginia Rail	*Rallus limicola*	Game species
Sora	*Porzana carolina*	Game species
Yellow Rail	*Coturnicops noveboracensis*	Ecologically significant
Black Rail	*Laterallus jamaicensis*	Undetermined (FCREPA)
Purple Gallinule	*Porphyrula martinica*	Ecologically significant
Common Gallinule	*Gallinula chloropus*	Game species
American Coot	*Fulica americana*	Game species
Jacana	*Jacana spinosa*	
American Oystercatcher	*Haematopus palliatus*	Blue-listed; threatened (FGFWFC, FCREPA)
Ringed Plover	*Charadrius hiaticula*	
Semipalmated Plover	*Charadrius semipalmatus*	
Piping Plover	*Charadrius melodus*	Blue-listed; special concern (FCREPA)
(Cuban) Snowy Plover	*Charadrius alexandrinus tenuirostris*	Blue-listed; endangered (FGFWFC, FCREPA)
Wilson's Plover	*Charadrius wilsonia*	
Killdeer	*Charadrius vociferus*	
American Golden Plover	*Pluvialis dominica*	
Black-bellied Plover	*Pluvialis squatarola*	
Ruddy Turnstone	*Arenaria interpres*	
American Woodcock	*Philohela minor*	Game species
Common Snipe	*Capella gallinago*	Game species
Long-billed Curlew	*Numenius americanus*	
Whimbrel	*Numenius phaeopus*	
Upland Sandpiper	*Bartramia longicauda*	Blue-listed
Spotted Sandpiper	*Actitis macularia*	
Solitary Sandpiper	*Tringa solitaria*	
Greater Yellowlegs	*Tringa melanoleuca*	
Lesser Yellowlegs	*Tringa flavipes*	
Willet	*Catoptrophorus semipalmatus*	
Red Knot	*Calidris canutus*	
Purple Sandpiper	*Calidris maritima*	
Pectoral Sandpiper	*Calidris melanotos*	
White-rumped Sandpiper	*Calidris fuscicollis*	
Baird's Sandpiper	*Calidris bairdii*	
Least Sandpiper	*Calidris minutilla*	
Semipalmated Sandpiper	*Calidris pusillus*	
Western Sandpiper	*Calidris mauri*	
Sanderling	*Calidris alba*	
Curlew Sandpiper	*Calidris ferruginea*	
Dunlin	*Calidris alpina*	
Ruff	*Philomachus pugnax*	
Short-billed Dowitcher	*Limnodromus griseus*	
Long-billed Dowitcher	*Limnodromus scolopaceus*	

Table 5.2. (Page 5 of 8)

BIRDS (CONTD)		
Common Name	Scientific Name	Special Status
Stilt Sandpiper	*Micropalama himantopus*	
Buff-breasted Sandpiper	*Tryngites subruficollis*	
Marbled Godwit	*Limosa fedoa*	
Hudsonian Godwit	*Limosa haemastica*	
American Avocet	*Recurvirostra americana*	Special concern (FCREPA)
Black-necked Stilt	*Himantopus mexicanus*	
Red Phalarope	*Phalaropus fulicarius*	
Wilson's Phalarope	*Steganopus tricolor*	
Northern Phalarope	*Lobipes lobatus*	
Parasitic Jaegar	*Stercorarius parasiticus*	
Long-tailed Jaegar	*Stercorarius longicaudus*	
Glaucous Gull	*Larus hyperboreus*	
Iceland Gull	*Larus glaucoides*	
Great Black-backed Gull	*Larus marinus*	
Lesser Black-backed Gull	*Larus fuscus*	
Herring Gull	*Larus argentatus*	
Ring-billed Gull	*Larus delawarensis*	
Black-headed Gull	*Larus ridibundus*	
Laughing Gull	*Larus atricilla*	
Franklin's Gull	*Larus pipixcan*	
Bonaparte's Gull	*Larus philadelphia*	
Black-legged Kittiwake	*Rissa tridactyla*	
Gull-billed Tern	*Gelochelidon nilotica*	Blue-listed
Forster's Tern	*Sterna forsteri*	
Common Tern	*Sterna hirundo*	
Roseate Tern	*Sterna dougallii*	Threatened (FGFWFC, FCREPA)
Sooty Tern	*Sterna fuscata*	
Bridled Tern	*Sterna anaethetus*	
Least Tern	*Sterna albifrons*	Blue-listed; threatened (FGFWFC, FCREPA)
Royal Tern	*Sterna maxima*	Special concern (FCREPA)
Sandwich Tern	*Sterna sandvicensis*	Special concern (FCREPA)
Caspian Tern	*Sterna caspia*	Special concern (FCREPA)
Black Tern	*Chlidonias niger*	
Noddy Tern	*Anous stolidus*	
Black Skimmer	*Rynchops niger*	Special concern (FCREPA)
White-winged Dove	*Zenaida asiatica*	Game species
White-crowned Pigeon	*Columba leucocephala*	
Rock Dove	*Columba livia*	
Band-tailed Pigeon	*Columba fasciata*	
Mourning Dove	*Zenaida macroura*	Game species
Ringed Turtle Dove	*Streptopelia risoria*	
Ground Dove	*Columbina passerina*	
exotic parrot	*Nandayus nenday*	
exotic parrot	*Aratinga jendaya*	
Canary-winged Parakeet	*Brotogeris versicolurus*	
Monk Parakeet	*Myiopsitta monachus*	
Budgerigar	*Melopsittacus undulatus*	
Mangrove Cuckoo	*Coccyzus minor*	Threatened (FGFWFC); rare (FCREPA)
Yellow-billed Cuckoo	*Coccyzus americanus*	Blue-listed
Black-billed Cuckoo	*Coccyzus erythropthalmus*	
Smooth-billed Ani	*Crotophaga ani*	
Groove-billed Ani	*Crotophaga sulcirostris*	
Barn Owl	*Tyto alba*	Blue-listed; ecologically significant
Screech Owl	*Otus asio*	Ecologically significant
Great Horned Owl	*Bubo virginianus*	Ecologically significant
(Florida) Burrowing Owl	*Athene cunicularia floridana*	Blue-listed; special concern (FCREPA)
Barred Owl	*Strix varia*	Ecologically significant
Short-eared Owl	*Asio flammeus*	Blue-listed; ecologically significant
Chuck-will's-widow	*Caprimulgus carolinensis*	
Whip-poor-will	*Caprimulgus vociferus*	
Common Nighthawk	*Chordeiles minor*	Blue-listed
Chimney Swift	*Chaetura pelagica*	
Ruby-throated Hummingbird	*Archilochus colubris*	
Rufous Hummingbird	*Selasphorus rufus*	
Belted Kingfisher	*Megaceryle alcyon*	Ecologically significant
Common Flicker	*Colaptes auratus*	
Pileated Woodpecker	*Dryocopus pileatus*	Ecologically significant
Red-bellied Woodpecker	*Melanerpes carolinus*	
Red-headed Woodpecker	*Melanerpes erythrocephalus*	Blue-listed; ecologically significant
Yellow-bellied Sapsucker	*Sphyrapicus varius*	
Hairy Woodpecker	*Picoides villosus audubonii*	Blue-listed, special concern (FCREPA)
Downy Woodpecker	*Picoides pubescens*	
Red-cockaded Woodpecker	*Picoides borealis*	Endangered (USDI, FGFWFC, FCREPA)
Ivory-billed Woodpecker	*Campephilus principalis*	Endangered (USDI, FGFWFC, FCREPA)
Eastern Kingbird	*Tyrannus tyrannus*	
Gray Kingbird	*Tyrannus dominicensis*	
Western Kingbird	*Tyrannus verticalis*	

Table 5.2. (Page 6 of 8)

BIRDS (CONTD)		
Common Name	Scientific Name	Special Status
Scissor-tailed Flycatcher	*Muscivora forficata*	
Great Crested Flycatcher	*Myiarchus crinitus*	
Eastern Phoebe	*Sayornis phoebe*	
Yellow-bellied Flycatcher	*Empidonax flaviventris*	
Acadian Flycatcher	*Empidonax virescens*	
Least Flycatcher	*Empidonax minimus*	
Traill's Flycatcher	*Empidonax traillii*	
Olive-sided Flycatcher	*Nuttallornis borealis*	
Eastern Wood Pewee	*Contopus virens*	
Vermilion Flycatcher	*Pyrocephalus rubinus*	
Horned Lark	*Eremophila alpestris*	
Bahama Swallow	*Callichelidon cyaneoviridis*	
Tree Swallow	*Iridoprocne bicolor*	
Bank Swallow	*Riparia riparia*	
Rough-winged Swallow	*Stelgidopteryx ruficollis*	
Barn Swallow	*Hirundo rustica*	
Cliff Swallow	*Petrochelidon pyrrhonota*	Blue-listed
Purple Martin	*Progne subis*	Blue-listed
Blue Jay	*Cyanocitta cristata*	
(Florida) Scrub Jay	*Aphelocoma coerulescens coerulescen*	Threatened (FGFWFC, FCREPA)
Common Crow	*Corvus brachyrhynchos*	
Fish Crow	*Corvus ossifragus*	
Carolina Chickadee	*Parus carolinensis*	
Tufted Titmouse	*Parus bicolor*	
White-breasted Nuthatch	*Sitta carolinensis carolinensis*	Special concern (FCREPA)
Red-breasted Nuthatch	*Sitta canadensis*	
Brown-headed Nuthatch	*Sitta pusilla*	Ecologically significant
Brown Creeper	*Certhia familiaris*	
House Wren	*Troglodytes aedon*	
Winter Wren	*Troglodytes troglodytes*	
Bewick's Wren	*Thryomanes bewickii*	Blue-listed
Carolina Wren	*Thryothorus ludovicianus*	
Long-billed Marsh Wren	*Cistothorus palustris*	
(Marian's) Marsh Wren	*Cistothorus palustris marianae*	Special concern (FCREPA)
Short-billed Marsh Wren	*Cistothorus platensis*	
Mockingbird	*Mimus polyglottos*	
Gray Catbird	*Dumetella carolinensis*	
Brown Thrasher	*Toxostoma rufum*	
American Robin	*Turdus migratorius*	
Wood Thrush	*Catharus mustelina*	
Hermit Thrush	*Catharus guttata*	
Swainson's Thrush	*Catharus ustulata*	
Gray-cheeked Thrush	*Catharus minima*	
Veery	*Catharus fuscescens*	
Eastern Bluebird	*Sialia sialis*	Blue-listed; ecologically significant
Blue-gray Gnatcatcher	*Polioptila caerulea*	
Golden-crowned Kinglet	*Regulus satrapa*	
Ruby-crowned Kinglet	*Regulus calendula*	
Water Pipit	*Anthus spinoletta*	
Sprague's Pipit	*Anthus spragueii*	
Cedar Waxwing	*Bombycilla cedrorum*	
Loggerhead Shrike	*Lanius ludovicianus*	Blue-listed; ecologically significant
Starling	*Sturnus vulgaris*	Ecologically significant
White-eyed Vireo	*Vireo griseus*	
Bell's Vireo	*Vireo bellii*	Blue-listed
Yellow-throated Vireo	*Vireo flavifrons*	
Solitary Vireo	*Vireo solitarius*	
Black-whiskered Vireo	*Vireo altiloquus*	Rare (FCREPA)
Red-eyed Vireo	*Vireo olivaceus*	
Philadelphia Vireo	*Vireo philadelphicus*	
Warbling Vireo	*Vireo gilvus*	
Black-and-white Warbler	*Mniotilta varia*	
Prothonotary Warbler	*Protonotaria citrea*	
Swainson's Warbler	*Limnothlypis swainsonii*	
Worm-eating Warbler	*Helmitheros vermivorus*	Special concern (FCREPA)
Bachman's Warbler	*Vermivora bachmanii*	Endangered (USDI, FGFWFC, FCREPA)
Golden-winged Warbler	*Vermivora chrysoptera*	
Blue-winged Warbler	*Vermivora pinus*	
(Lawrence's Warbler)	*Vermivora lawrencei*	Hybrid
(Brewster's Warbler)	*Vermivora leucobronchialis*	Hybrid
Tennessee Warbler	*Vermivora peregrina*	
Orange-crowned Warbler	*Vermivora celata*	
Nashville Warbler	*Vermivora ruficapilla*	
Northern Parula	*Parula americana*	
Yellow Warbler	*Dendroica petechia*	Blue-listed
Magnolia Warbler	*Dendroica magnolia*	
Cape May Warbler	*Dendroica tigrina*	
Black-throated Blue Warbler	*Dendroica caerulescens*	

Table 5.2. (Page 7 of 8)

BIRDS (CONTD)		
Common Name	Scientific Name	Special Status
Yellow-rumped Warbler	*Dendroica coronata*	
Black-throated Gray Warbler	*Dendroica nigrescens*	
Black-throated Green Warbler	*Dendroica virens*	
Cerulean Warbler	*Dendroica cerulea*	
Blackburnian Warbler	*Dendroica fusca*	
Yellow-throated Warbler	*Dendroica dominica*	
Chestnut-sided Warbler	*Dendroica pensylvanica*	
Bay-breasted Warbler	*Dendroica castanea*	
Blackpoll Warbler	*Dendroica striata*	
Kirtland's Warbler	*Dentroica kirtlandii*	Endangered (USDI, FGFWFC, FCREPA)
(Sutton's Warbler)	*(Dendroica potomac)*	Hybrid
Pine Warbler	*Dendroica pinus*	
Prairie Warbler	*Dendroica discolor*	
(Florida) Prairie Warbler	*Dendroica discolor paludicola*	Special concern (FCREPA)
Palm Warbler	*Dendroica palmarum*	
Ovenbird	*Seiurus aurocapillus*	
Northern Waterthrush	*Seiurus noveboracensis*	
Louisiana Waterthrush	*Seiurus motacilla*	Rare (FCREPA)
Kentucky Warbler	*Oporornis formosus*	
Connecticut Warbler	*Oporornis agilis*	
Mourning Warbler	*Oporornis tolmiei*	
Common Yellowthroat	*Geothlypis trichas*	
Yellow-breasted Chat	*Icteria virens*	Blue-listed
Hooded Warbler	*Wilsonia citrina*	
Wilson's Warbler	*Wilsonia pusilla*	
Canada Warbler	*Wilsonia canadensis*	
American Redstart	*Setophaga ruticilla ruticilla*	Rare breeder (FCREPA) Ecologically significant
House Sparrow	*Passer domesticus*	
Bobolink	*Dolichonyx oryzivorus*	
Eastern Meadowlark	*Sturnella magna*	
Western Meadowlark	*Sturnella neglecta*	
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	
Red-winged Blackbird	*Agelaius phoeniceus*	
Orchard Oriole	*Icterus spurius*	
Spotted-breasted Oriole	*Icterus pectoralis*	
Northern Oriole	*Icterus galbula*	
Rusty Blackbird	*Euphagus carolinus*	
Brewer's Blackbird	*Euphagus cyanocephalus*	
Boat-tailed Grackle	*Quiscalus mexicanus*	
Common Grackle	*Quiscalus quiscula*	
Brown-headed Cowbird	*Molothrus ater*	
Bronzed Cowbird	*Molothrus aeneus*	
Blue-gray Tanager	*Thraupis virens*	
Western Tanager	*Piranga ludoviciana*	
Scarlet Tanager	*Piranga olivacea*	
Summer Tanager	*Piranga rubra*	
Cardinal	*Cardinalis cardinalis*	
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	
Black-headed Grosbeak	*Pheucticus melanocephalus*	
Blue Grosbeak	*Guiraca caerulea*	
Indigo Bunting	*Passerina cyanea*	
Painted Bunting	*Passerina ciris*	
Dickcissel	*Spiza americana*	
Evening Grosbeak	*Hesperiphona vespertina*	
Purple Finch	*Carpodacus purpureus*	
Pine Siskin	*Carduelis pinus*	
American Goldfinch	*Carduelis tristis*	
Rufous-sided Towhee	*Pipilo erythrophthalmus*	
Savannah Sparrow	*Passerculus sandwichensis*	
Grasshopper Sparrow	*Ammodramus savannarum*	
(Florida) Grasshopper Sparrow	*Ammodramus savannarum floridanus*	Endangered (FGFWFC, FCREPA) Blue-listed
Henslow's Sparrow	*Ammodramus henslowii*	
LeConte's Sparrow	*Ammospiza leconteii*	
Sharp-tailed Sparrow	*Ammospiza caudacuta*	
(Scott's) Seaside Sparrow	*Ammospiza maritima peninsulae*	Special concern (FCREPA) Blue-listed
Vesper Sparrow	*Pooecetes gramineus*	
Lark Sparrow	*Chondestes grammacus*	
Bachman's Sparrow	*Aimophila aestivalis*	Blue-listed; ecologically significant
Dark-eyed Junco	*Junco hyemalis*	
Chipping Sparrow	*Spizella passerina*	
Clay-colored Sparrow	*Spizella pallida*	
Field Sparrow	*Spizella pusilla*	
White-crowned Sparrow	*Zonotrichia leucophrys*	
White-throated Sparrow	*Zonotrichia albicollis*	
Fox Sparrow	*Passerella iliaca*	
Lincoln's Sparrow	*Melospiza lincolnii*	
Swamp Sparrow	*Melospiza georgiana*	
Song Sparrow	*Melospiza melodia*	
Lapland Longspur	*Calcarius lapponicus*	
Snow Bunting	*Plectrophenax nivalis*	

Table 5.2. (Page 8 of 8)

MAMMALS		
Common Name	**Scientific Name**	**Special Status**
Opossum	*Didelphis virginiana*	
Southeastern Shrew	*Sorex longirostris longirostris*	Rare (FCREPA)
Short-tailed Shrew	*Blarina brevicauda*	Ecologically significant
Least Shrew	*Cryptotis parva*	
Eastern Mole	*Scalopus aquaticus*	
Southeastern Myotis	*Myotis austroriparius*	
Eastern Pipistrelle	*Pipistrellus subflavus*	
Big Brown Bat	*Eptesicus fuscus*	Rare (FCREPA)
Red Bat	*Lasiurus borealis*	
Seminole Bat	*Lasiurus seminolus*	
Hoary Bat	*Lasiurus cinereus cinereus*	Rare (FCREPA)
Northern Yellow Bat	*Lasiurus intermedius*	Ecologically significant
Evening Bat	*Nycticeius humeralis*	
Eastern Big-eared Bat	*Plecotus rafinesquii*	Rare (FCREPA)
Mexican Free-tailed Bat	*Tadarida brasiliensis*	
Nine-banded Armadillo	*Dasypus novemcinctus*	Ecologically significant
Marsh Rabbit	*Sylvilagus palustris*	Game species
Eastern Cottontail Rabbit	*Sylvilagus floridanus*	Game species
Black-tailed Jack Rabbit	*Lepus californicus*	Ecologically significant
Eastern Gray Squirrel	*Sciurus carolinensis*	Game species
Sherman's Fox Squirrel	*Sciurus niger shermani*	Threatened (FGFWFC, FCREPA)
Southern Flying Squirrel	*Glaucomys volans*	
Southeastern Pocket Gopher	*Geomys pinetis*	Ecologically significant
Rice Rat	*Oryzomys palustris*	
Eastern Harvest Mouse	*Reithrodontomys humulis*	Ecologically significant
Oldfield Mouse	*Peromyscus polionotus*	
Cotton Mouse	*Peromyscus gossypinus*	
Florida Mouse	*Peromyscus floridanus*	Threatened (FGFWFC, FCREPA)
Golden Mouse	*Ochrotomys nuttalli*	Ecologically significant
Hispid Cotton Rat	*Sigmodon hispidus*	
Eastern Woodrat	*Neotoma floridana*	Ecologically significant
Round-tailed Muskrat	*Neofiber alleni*	Protected fur bearer (FGFWFC); special concern (FCREPA)
Black Rat	*Rattus rattus*	Pest species
Norway Rat	*Rattus norvegicus*	Pest species
House Mouse	*Mus musculus*	Pest species
Nutria	*Myocastor coypus*	Economically significant
Bottle-nosed Dolphin	*Tursiops truncatus*	Ecologically significant
Coyote	*Canis latrans*	Ecologically significant
Red Fox	*Vulpes fulva*	Fur bearer
Gray Fox	*Urocyon cinereoargenteus*	Fur bearer
Florida Black Bear	*Ursus americanus floridanus*	Game species; threatened (FGFWFC, FCREPA)
Raccoon	*Procyon lotor*	Fur bearer
Florida Long-tailed Weasel	*Mustela frenata peninsulae*	Rare (FCREPA)
Florida Mink	*Mustela vison lutensis*	Fur bearer; rare (FCREPA)
Eastern Spotted Skunk	*Spilogale putorius*	Fur bearer
Striped Skunk	*Mephitis mephitis*	Fur bearer
River Otter	*Lutra canadensis*	Fur bearer; ecologically significant
Florida Panther	*Felis concolor coryi*	Endangered (USDI, FGFWFC, FCREPA)
Bobcat	*Felis rufus*	Fur bearer; ecologically significant
Jaguarundi	*Felis yagouaroundi*	Ecologically significant
Manatee	*Trichechus manatus latirostris*	Endangered (USDI); threatened (FGFWFC, FCREPA)
White-tailed Deer	*Odocoileus virginianus*	Game species
Wild Hog	*Sus scrofa*	Game species
Dog	*Canis familiaris*	
Cat	*Felis catus*	

Florida Committee on Rare and Endangered Plants and Animals (FCREPA). Pertaining only to birds is the Blue List of species currently experiencing noncyclical population declines or range contractions, either locally or widespread. Initiated in 1971 by the journal American Birds, the list is updated and published annually. Table 5.2 indicates the species on the 1976 list (Arbib 1977).

The entire assemblage of vertebrates (excluding fishes) in the study area comprises some 28 amphibians, 68 reptiles, 384 birds, and 55 mammals.

Distribution (presence and relative abundance) of these species among several terrestrial and aquatic habitat types, both natural and man-modified, is indicated in Table 5.3. Since many birds are migratory, their residence status within the study area is indicated as well as their distribution.

The data in Tables 5.2 and 5.3 were obtained from numerous sources other than those mentioned; they are listed in the bibliography that applies to all volumes of this report.

b. Threatened and Endangered Species

The federal law pertaining to threatened and endangered species was a response to several vertebrate species' recent extinction (e.g, Passenger Pigeon, Carolina Parakeet) or possible extinction (e.g., Ivory-billed Woodpecker). Increased public awareness of the plight of these species as well as the pending plight of others prompted an initial federal law, The Endangered Species Conservation Act of 1969 (U.S. Public Law 91-135; 83 Stat. 275), which was superseded by the Endangered Species Act of 1973 (U.S. Public Law 93-205; 87 Stat. 884), mentioned in the discussion of threatened and endangered plants. Referring specifically to vertebrates and later to other biota, the laws seek "...to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions..."

Table 5.3. Distribution and Relative Abundance* of Amphibians, Reptiles, Birds, and Mammals within Habitat Types of Study Area (Page 1 of 9)

Species	Seasonal Status†	Terrestrial and Wetland Types																	Aquatic Types						Man-Modified‡
		Forest and Woodlands											Nonforest/ Herbaceous						Fresh Water				Marine		
		Pine-Oak		Pine Flatwoods		Hammocks			Wetland				Brushland		Prairies		Marshes		Lakes	Ponds	Springs	Streams	Coastal	Offshore	
		Sand Hills	Scrub	Scrub	Typical	Cabbage Palm	Mesic	Live Oak	Bayhead	Mixed Hardwoods	Cypress	Mangrove	Dry	Swamp	Dry	Wet	Fresh	Salt							
AMPHIBIANS																									
Peninsula Newt		-	-	-	-	-	-	-	-	C	U	-	-	-	-	-	U	-	U	A	U	C	-	-	C11-13
Dwarf Siren		-	-	-	-	-	-	-	-	C	U	-	-	-	-	-	C	-	C	U	R	U	-	-	U11-13
Lesser Siren		-	-	-	-	-	-	-	-	C	U	-	-	-	-	-	-	-	-	C	U	U	-	-	U11-13
Greater Siren		-	-	-	-	-	-	-	-	C	U	-	-	-	-	-	U	-	U	A	U	C	-	-	C11-13
Two-toed Amphiuma		-	-	-	-	-	-	-	-	A	U	-	-	-	-	-	U	-	C	R	U	U	-	-	U11-13
Southern Dusky Salamander		-	-	-	-	-	-	-	-	R	C	-	-	R	-	-	R	-	-	R	-	-	-	-	
Dwarf Salamander		-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	R	-	R	R	-	-	-	-	
Slimy Salamander		-	-	-	-	-	-	-	-	R	-	-	-	R	-	-	-	-	U	U	-	-	-	-	
Eastern Spadefoot Toad		C	C	-	R	-	R	-	-	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	C
Oak Toad		C	C	C	C	U	U	C	-	U	C	-	C	-	A	A	-	-	-	-	-	-	-	-	C1-9
Southern Toad		C	U	U	C	U	C	C	-	C	C	-	-	-	C	U	U	-	-	-	-	-	-	-	C1-9
Giant Toad		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C8,15
Eastern Narrowmouth Toad		C	C	U	C	U	C	U	-	C	C	-	U	C	C	U	U	-	-	-	-	-	-	-	C5-6
Southern Leopard Frog		C	-	-	U	-	-	-	-	A	A	-	-	C	-	A	A	-	A	A	C	C	-	-	C11-13,16
Florida Gopher Frog		U	U	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Bronze Frog		-	-	-	-	-	-	-	-	R	R	-	-	-	-	-	-	-	R	R	R	-	-	-	
Bullfrog		-	-	-	-	-	-	-	R	C	C	-	-	-	-	C	C	-	C	U	U	U	-	-	C11-13,16
Pig Frog		-	-	-	U	-	-	-	R	C	C	-	-	-	-	A	A	-	C	C	-	C	-	-	C11-13,16
Greenhouse Frog		R	-	-	U	-	U	-	-	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	U7-9
Southern Cricket Frog		R	-	-	R	-	-	-	C	C	A	-	-	-	-	A	A	-	A	A	U	C	-	-	
Green Treefrog		R	C	-	C	-	-	-	C	C	A	-	-	-	-	A	C	-	C	C	-	C	-	-	C16
Cuban Treefrog		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C7-9
Pine Woods Treefrog		C	-	-	C	-	U	-	U	C	C	-	-	-	-	-	U	-	-	U	R	R	-	-	U11-13,16
Barking Treefrog		U	-	-	U	-	-	-	-	R	R	-	-	-	-	U	U	-	-	U	R	R	-	-	R16
Squirrel Treefrog		C	-	-	C	-	C	-	C	A	C	-	-	-	C	C	A	-	C	C	C	C	-	-	U16
Little Grass Frog		R	-	-	U	-	-	-	-	-	U	-	-	-	U	C	C	-	U	C	U	U	-	-	U13
Southern Chorus Frog		-	-	-	U	-	-	-	U	C	C	-	-	-	-	C	C	-	U	U	U	-	-	-	C13
Ornate Chorus Frog		-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	-	-	-	-	-	-	
REPTILES																									
American Alligator		-	-	U	-	-	-	-	C	C	R	U	-	-	-	U	C	-	C	U	-	A	-	-	C2,11-13
Snapping Turtle		-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	U	-	C	U	U	C	-	-	C11-13
Striped Mud Turtle		-	-	-	-	-	-	-	-	U	U	-	-	U	-	U	C	-	C	C	R	C	-	-	C11-13
Mud Turtle		-	-	-	-	-	-	-	-	U	U	-	-	U	-	U	C	-	C	C	R	C	-	-	U11-13
Stinkpot Turtle		-	-	-	-	-	-	-	-	U	U	-	-	-	-	-	U	-	U	C	-	U	-	-	U11-13
Eastern Box Turtle		R	-	-	C	-	U	U	-	C	-	-	-	-	C	U	-	-	-	-	-	-	-	-	C2,5
Diamondback Terrapin		-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	U	-	-	-	-	-	-	
Suwannee Cooter		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	R	R	-	R	
Peninsular Cooter		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	A	A	U	C	-	-	C11-13
Florida Red-bellied Turtle		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	U	U	R	C	-	-	U11-13
Chicken Turtle		-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	C	-	A	C	U	A	-	-	C11-13

* A Abundant R Rare
C Common ? Status unknown
U Uncommon

† Applicable to birds only:
P Permanent resident M Migrant
S Summer resident (visitor) A Accidental (vagrant)
W Winter resident (visitor) E Possibly extinct

‡ 1 Plantations 9 Urban
2 Parklands 10 Industrial
3 Grasslands 11 Freshwater lakes
4 Active croplands 12 Freshwater ponds
5 Old fields 13 Freshwater canals and ditches
6 Barren lands 14 Marine impoundments
7 Rural 15 Marine canals and ditches
8 Suburban 16 Wetlands

Table 5.3. (Page 2 of 9)

Species	Seasonal Status†	Terrestrial and Wetland Types																	Aquatic Types						Man-Modified†
		Forest and Woodlands											Nonforest/ Herbaceous						Fresh Water				Marine		
		Pine-Oak		Pine Flatwoods		Hammocks			Wetland				Brushland		Prairies		Marshes		Lakes	Ponds	Springs	Streams	Coastal	Offshore	
		Sand Hills	Scrub	Scrub	Typical	Cabbage Palm	Mesic	Live Oak	Bayhead	Mixed Hardwoods	Cypress	Mangrove	Dry	Swamp	Dry	Wet	Fresh	Salt							
REPTILES (CONTD)																									
Gopher Tortoise		U	-	U	U	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	
Florida Softshell Turtle		-	-	-	-	-	-	-	-	-	R	-	-	-	-	R	C	-	C	A	C	C	-	-	C11-13
Atlantic Leatherback Turtle		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	
Atlantic Loggerhead Turtle		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	
Atlantic Ridley Turtle		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	
Atlantic Green Turtle		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	
Worm Lizard		U	-	-	R	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	
Gecko		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U7-9
Mediterranean Gecko		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U7-9
Green Anole		A	-	-	C	C	C	-	-	C	C	-	-	-	C	C	-	-	-	-	-	-	-	-	C1-2,7-9
Brown Anole		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	U7-9
Texas Horned Lizard		R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Fence Lizard		A	C	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Florida Scrub Lizard		U	U	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Six-lined Racerunner		C	-	R	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Southeastern Five-lined Skink		C	-	R	U	-	R	-	-	C	U	-	-	-	-	-	-	-	-	-	-	-	-	-	
Blue-tailed Mole Skink		C	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Peninsula Mole Skink		C	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Broad-headed Skink		U	U	-	-	-	-	U	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Sand Skink		C	U	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Ground Skink		C	-	-	R	-	C	-	-	A	U	-	-	-	-	-	-	-	-	-	-	-	-	-	
Slender Glass Lizard		R	-	-	U	-	-	U	-	-	-	-	-	-	C	-	-	-	-	-	-	-	U	-	
Island Glass Lizard		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	
Eastern Glass Lizard		U	-	U	U	-	U	U	-	-	-	-	-	-	U	-	-	-	-	-	-	-	U	-	C1
Scarlet Snake		R	-	-	R	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	
Black Racer Snake		A	C	C	A	U	U	C	-	C	C	-	C	C	C	C	C	-	-	-	-	-	-	-	C1-9
Eastern Ringneck Snake		U	-	-	U	-	C	-	-	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	
Eastern Indigo Snake		U	U	U	U	-	U	-	-	U	U	-	-	-	U	-	-	-	-	-	-	-	-	-	
Corn Snake		U	-	U	U	-	-	-	-	R	R	-	-	-	U	-	-	-	-	-	-	-	-	-	
Yellow Rat Snake		U	U	U	U	-	U	U	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Mud Snake		-	-	-	-	-	-	-	-	R	U	-	-	U	-	U	C	-	U	U	R	U	-	-	U13
Rainbow Snake**		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Eastern Hognose Snake		C	U	U	U	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Southern Hognose Snake		R	R	R	R	-	-	-	-	U	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Scarlet Kingsnake		U	R	R	U	-	U	-	-	U	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Florida Kingsnake**		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Striped Swamp Snake		-	-	-	-	-	-	-	-	R	R	-	-	-	-	U	C	-	U	U	U	U	-	-	
Eastern Coachwhip Snake		U	-	-	R	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	
Green Water Snake		-	-	-	-	-	-	-	-	R	R	-	-	-	-	-	U	C	C	U	-	U	-	-	U15
Florida Water Snake		-	-	-	-	-	-	-	-	U	U	-	-	-	-	A	C	-	C	C	U	C	-	-	C11-13,16
Mangrove Water Snake		-	-	-	-	-	-	-	-	-	-	U	-	-	-	R	R	U	-	-	-	-	R	-	
Brown Water Snake		-	-	-	-	-	-	-	-	R	U	-	-	-	-	-	R	-	U	C	U	C	-	-	U11-13,16
Rough Green Snake		U	-	-	U	-	R	R	U	R	R	-	-	-	R	-	-	-	-	-	-	-	-	-	R5-6
Pine Snake		R	R	R	R	-	-	R	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Pine Woods Snake		R	-	-	R	-	R	-	-	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Florida Swamp Snake		-	-	-	-	-	-	-	-	U	U	-	-	-	-	U	C	-	U	U	-	U	-	-	U11-13,16
Short-tailed Snake		U	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Florida Brown Snake		R	-	-	R	-	U	U	-	U	R	-	-	U	-	C	C	-	U	U	-	U	-	-	U11-13,16
Red-bellied Snake		-	-	-	-	-	-	-	-	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Florida Crowned Snake		U	-	-	R	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Ribbon Snake		C	U	U	U	-	U	-	-	C	U	-	-	U	-	C	R	-	C	C	-	U	-	-	U11-13,16
Eastern Garter Snake		C	U	U	C	U	U	U	U	C	U	-	U	U	U	C	C	-	C	C	U	U	-	-	C11-13,16
Smooth Earth Snake		-	-	-	-	-	-	U	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Eastern Coral Snake		R	-	-	R	-	R	R	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Cottonmouth Moccasin		-	-	-	R	-	-	-	-	C	C	-	-	-	-	U	C	-	U	U	R	R	R	-	R11-13,16
Eastern Diamondback Rattlesnake		R	-	C	U	-	U	-	-	-	R	-	U	-	C	U	-	-	-	-	-	-	-	-	
Pigmy Rattlesnake		-	-	U	U	-	U	C	-	U	R	-	-	-	-	-	-	-	-	-	-	-	-	-	

**Present in study area, distribution unknown

Table 5.3. (Page 3 of 9)

Species	Seasonal Status†	Terrestrial and Wetland Types																	Aquatic Types						Man-Modified†
		Forest and Woodlands											Nonforest/ Herbaceous						Fresh Water				Marine		
		Pine-Oak		Pine Flatwoods		Hammocks			Wetland				Brushland		Prairies		Marshes		Lakes	Ponds	Springs	Streams	Coastal	Offshore	
		Sand Hills	Scrub	Scrub	Typical	Cabbage Palm	Mesic	Live Oak	Bayhead	Mixed Hardwoods	Cypress	Mangrove	Dry	Swamp	Dry	Wet	Fresh	Salt							
BIRDS																									
Common Loon	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	R	U	-	
Arctic Loon	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	
Red-throated Loon	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	
Red-necked Grebe	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	
Horned Grebe	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	R	C	-	
Eared Grebe	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Western Grebe	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Pied-billed Grebe	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	-	U	-	-	C11,12,13
Leach's Storm-Petrel	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Wilson's Storm-Petrel	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	
White Pelican	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	U	U	-	U11
Brown Pelican	P	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	R	-	-	R	C	-	
Blue-faced Booby	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Brown Booby	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Great Cormorant	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Double-crested Cormorant	P	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	C	-	-	C	A	-	C11
Anhinga	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	C	C	-	C11,12
Magnificent Frigatebird	P	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	R	-	-	R	U	-	
Great Blue Heron	P	-	-	-	-	-	-	-	-	U	U	C	-	C	-	C	C	C	C	C	-	C	C	-	C11-16
(Great White Heron)	P	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	R	-	-	-	R	-	
Green Heron	P	-	-	-	-	-	-	-	C	C	C	C	-	C	-	C	C	C	C	C	-	C	C	-	C11-16
Little Blue Heron	P	-	-	-	-	-	-	-	C	C	C	C	-	C	-	C	C	C	C	C	-	C	C	-	C11-16
Cattle Egret	P	-	-	U	C	-	-	-	C	C	C	-	-	-	A	C	C	-	U	C	-	U	U	-	A3; C2,5,11-13
Reddish Egret	P	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	R	-	
Great Egret	P	-	-	-	-	-	-	-	C	C	C	C	-	C	-	C	C	C	C	C	-	C	C	-	C11-13,16
Snowy Egret	P	-	-	-	-	-	-	-	-	-	C	A	-	C	-	C	C	C	C	C	-	C	C	-	C11-13,16
Louisiana Heron	P	-	-	-	-	-	-	-	-	-	C	C	-	C	-	C	C	C	C	C	-	C	C	-	C11-13,16
Black-crowned Night Heron	P	-	-	-	-	-	-	-	-	-	U	C	-	U	-	U	U	U	U	U	-	U	U	-	U11-13,16
Yellow-crowned Night Heron	P	-	-	-	-	-	-	-	-	-	U	C	-	C	-	U	U	C	U	U	-	U	U	-	U11-13,16
Least Bittern	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	U	-	-	-	-	-	-	U16
American Bittern	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	U	-	-	-	-	-	-	U16
Wood Stork	P	-	-	-	-	-	-	-	-	-	U	U	-	-	-	U	U	-	-	-	-	-	-	-	U16
Glossy Ibis	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	U	U	U	-	U	-	-	U16
White Ibis	R	-	-	-	-	-	-	-	-	-	-	A	-	-	-	C	C	-	C	C	-	C	C	-	C16
Scarlet Ibis**	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Roseate Spoonbill	S	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	C	C	-	C	C	-	
American Flamingo**	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Whistling Swan	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	R	R	-	C11,12
Canada Goose	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	R	R	-	C3,11,12
Brant	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Snow Goose	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	R	-	-	C3,11,12
Fulvous Whistling-Duck	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	R	R	-	-	-	-	R11,12
Ruddy Sheld-Duck**	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Mallard	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	R	R	-	R	-	-	R11,12
Black Duck	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	R	R	-	R	-	-	R11,12
Mottled Duck	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	-	C	C	-	C	-	-	C4,11-13,16
Gadwall	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	R	-	-	R11,12
Pintail	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	U	-	-	U11,12
Cinnamon Teal	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Green-winged Teal	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	-	C	-	-	C11,12
Blue-winged Teal	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	C	C	-	C	-	-	C11,12
European Wigeon	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
American Wigeon	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	-	C	-	-	C11,12
Northern Shoveler	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	U	-	-	U11,12
Wood Duck	P	-	-	-	-	-	-	-	C	C	C	-	-	C	-	U	U	-	U	U	-	U	-	-	U11,12,16
Redhead	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	R	-	-	R11,12
Ring-necked Duck	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	C	C	-	C	-	-	C11,12,16
Canvasback	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	R	-	-	R11,12
Greater Scaup	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	
Lesser Scaup	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	C	C	-	C	A	-	C11,12

** Escapees observed in wild

Table 5.3. (Page 4 of 9)

Species	Seasonal Status *	Terrestrial and Wetland Types																	Aquatic Types						Man-Modified!
		Forest and Woodlands											Nonforest/ Herbaceous						Fresh Water				Marine		
		Pine-Oak		Pine Flatwoods		Hammocks			Wetlands				Brushland		Prairies		Marshes		Lakes	Ponds	Springs	Streams	Coastal	Offshore	
		Sand Hills	Scrub	Scrub	Typical	Cabbage Palm	Mesic	Live Oak	Bayhead	Mixed Hardwoods	Cypress	Mangrove	Dry	Swamp	Dry	Wet	Fresh	Salt							
BIRDS (CONT'D)																									
Common Goldeneye	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	
Bufflehead	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	R	R	-	
Oldsquaw	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	
Common Eider	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	
White-winged Scoter	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	
Surf Scoter	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	
Black Scoter	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	
Ruddy Duck	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	U	R	-	U11,12
Masked Duck	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Hooded Merganser	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	U	-	-	U11
Common Merganser	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	R	R	-	R11
Red-breasted Merganser	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	U	A	-	U11
Turkey Vulture***	P	C	C	A	A	C	C	C	C	C	C	-	C	-	C	C	-	-	-	-	-	-	-	-	C1-7
Black Vulture***	P	C	C	A	A	C	C	C	C	C	C	-	C	-	C	C	-	-	-	-	-	-	-	-	C1-7
White-tailed Kite	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R1-5
Swallow-tailed Kite	S	-	-	U	U	U	U	U	U	U	U	-	U	U	U	U	U	-	-	-	-	-	-	-	U1-5
Mississippi Kite	W	R	R	R	R	R	R	R	R	R	R	-	R	R	R	R	R	-	-	-	-	-	-	-	R1-5
(Florida) Everglade Kite	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	-	-	-	-	-	-	
Sharp-shinned Hawk	W	U	U	-	U	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	
Cooper's Hawk	P	R	U	-	U	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	
Red-tailed Hawk	P	U	U	U	U	C	U	U	U	U	U	-	U	-	U	-	-	-	-	-	-	-	-	-	
Red-shouldered Hawk	P	C	C	C	C	C	C	C	C	C	C	-	C	C	C	C	-	-	-	-	-	-	-	-	C1-5
Broad-winged Hawk	W	-	-	-	U	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	
Swainson's Hawk	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Short-tailed Hawk	P	-	-	-	-	-	-	-	R	R	R	-	-	R	-	R	-	-	-	-	-	-	-	-	
Rough-legged Hawk	W	-	-	R	R	-	-	-	-	-	-	-	-	-	R	R	-	-	-	-	-	-	-	-	R3-5
Golden Eagle	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Bald Eagle	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	U	U	U	U	-	U	U	-	U11,12
Marsh Hawk	W	-	-	-	-	-	-	-	-	-	-	-	C	-	C	C	C	C	-	-	-	-	-	-	C3-5,16
Osprey	P	-	-	-	-	-	-	-	-	-	-	U	-	-	-	U	U	U	U	U	-	U	-	-	C11,12
Caracara	P	-	-	R	R	-	-	-	-	-	-	-	R	-	R	-	-	-	-	-	-	-	-	-	R3-5
Peregrine Falcon	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	-	-	-	-	R	-	
Merlin	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	-	-	-	-	R	-	
American Kestrel	W	-	-	U	U	-	-	-	-	-	-	-	-	-	C	C	C	C	-	-	-	-	C	-	C3-5,7-9
(Southeastern) American Kestrel	P	-	-	U	U	-	-	-	-	-	-	-	-	-	U	U	U	U	-	-	-	-	U	-	U3-5,7-9
Bobwhite	P	-	-	U	U	-	U	U	-	-	-	-	R	-	C	U	-	-	-	-	-	-	-	-	C3-5
Chukar**	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Black Francolin**	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Turkey	P	U	U	U	U	U	U	U	-	U	-	-	U	-	U	U	-	-	-	-	-	-	-	-	U3-5
(Greater) Sandhill Crane	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	-	-	-	-	-	-	U2-5
(Florida) Sandhill Crane	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	-	-	-	-	-	-	U2-5
African Crowned Crane**	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Limpkin	P	-	-	-	-	-	-	-	R	R	-	-	-	R	-	-	R	-	-	-	-	R	-	-	R13,16
King Rail	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	U	R	-	-	-	-	-	-	U16
Clapper Rail	A	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	C	-	-	-	-	-	-	
(Florida) Clapper Rail	P	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	C	-	-	-	-	-	-	
Virginia Rail	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	U	-	-	-	-	-	-	U16
Sora	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	C	U	-	-	-	-	-	-	U16
Yellow Rail	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	-	-	-	-	-	-	R16
Black Rail	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	-	-	-	-	-	-	R16
Purple Gallinule	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	U	U	-	U	-	-	U11-13,16
Common Gallinule	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	-	C	C	-	C	-	-	C11-13,16
American Coot	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	A	U	A	A	-	A	U	-	A11-13,16
Jacana	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
American Oystercatcher	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	
Ringed Plover	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Semipalmated Plover	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	C	-	
Piping Plover	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	
(Cuban) Snowy Plover	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	
Wilson's Plover	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	
Killdeer	P	-	-	-	-	-	-	-	-	-	-	-	-	-	U	C	U	-	C	-	-	-	U	-	C2,3;U5-13
American Golden Plover	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	R2,3
Black-bellied Plover	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	C	-	

** Escapees observed in wild.

*** Occurs in open air over all types of terrain.

Table 5.3. (Page 5 of 9)

Species	Seasonal Status	Terrestrial and Wetland Types																	Aquatic Types						Man-Modified
		Forest and Woodlands											Nonforest/ Herbaceous						Fresh Water				Marine		
		Pine-Oak		Pine Flatwoods		Hammocks			Wetland				Brushland		Prairies		Marshes		Lakes	Ponds	Springs	Streams	Coastal	Offshore	
		Sand Hills	Scrub	Scrub	Typical	Cabbage Palm	Mesic	Live Oak	Bayhead	Mixed Hardwoods	Cypress	Mangrove	Dry	Swamp	Dry	Wet	Fresh	Salt							
Ruddy Turnstone	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	
American Woodcock	W	-	-	-	-	-	-	-	-	R	-	-	-	R	-	-	-	-	-	-	-	-	-	-	
Common Snipe	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	-	C	C	-	C	-	-	C11-13
Long-billed Curlew	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	
Whimbrel	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	-	-	-	U	-	
Upland Sandpiper	M	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	R2-3
Spotted Sandpiper	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	U	U	-	U11-13,15
Solitary Sandpiper	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	U	-	-	
Greater Yellowlegs	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	-	C	C	-	U	C	-	C11-13,15
Lesser Yellowlegs	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	-	C	C	-	U	C	-	C11-13,15
Willet	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	R	-	-	-	A	-	
Red Knot	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	
Purple Sandpiper	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	
Pectoral Sandpiper	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	-	U	-	-	-	-	U3
White-rumped Sandpiper	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	-	U	-	
Baird's Sandpiper	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	-	R	-	
Least Sandpiper	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	-	-	C	-	C11,12
Semipalmated Sandpiper	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	-	U	-	U11,12
Western Sandpiper	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	-	-	C	-	C11,12
Sanderling	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	
Curlew Sandpiper	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Dunlin	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	
Ruff	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	-	-	-	-	C11,12
Short-billed Dowitcher	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	C	C	-	-	C	-	C11,12
Long-billed Dowitcher	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	R	R	-	-	R	-	R11,12
Stilt Sandpiper	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	R	R	-	-	R	-	R11,12
Buff-breasted Sandpiper	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	R	R	-	-	R	-	R11,12
Marbled Godwit	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	R	R	-	-	R	-	R11,12
Hudsonian Godwit	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	R	R	-	-	R	-	R11,12
American Avocet	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	R	-	R11
Black-necked Stilt	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	-	U	-	U11,12
Red Phalarope	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	
Wilson's Phalarope	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	R	R	
Northern Phalarope	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	
Parasitic Jaeger	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Long-tailed Jaeger	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Glaucous Gull	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	
Iceland Gull	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	R	-	
Great Black-backed Gull	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	
Lesser Black-backed Gull	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Herring Gull	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	C	-	U11
Ring-billed Gull	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	C	-	U11
Black-headed Gull	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Laughing Gull	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	A	-	U11
Franklin's Gull	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Bonaparte's Gull	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	U	-	R11
Black-legged Kittiwake	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Gull-billed Tern	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	R	-	R11
Forster's Tern	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	C	-	U11
Common Tern	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	U	-	R11
Roseate Tern	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	
Sooty Tern	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Bridled Tern	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Least Tern	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	C	-	R8-10
Royal Tern	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	C	-	U11
Sandwich Tern	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	A	-	U11
Caspian Tern	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	U	-	R11
Black Tern	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-	A	-	C11
Noddy Tern	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Black Skimmer	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	C	-	U11
White-winged Dove	W	-	-	R	R	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	
White-crowned Pigeon	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Table 5.3. (Page 6 of 9)

		Terrestrial and Wetland Types																	Aquatic Types						
		Forest and Woodlands											Nonforest/ Herbaceous						Fresh Water				Marine		
		Pine Oak		Pine Flatwoods		Hammocks			Wetland				Brushland		Prairies		Marshes								
	Seasonal Status	Sand Hills	Scrub	Scrub	Typical	Cabbage Palm	Mesic	Live Oak	Bayhead	Mixed Hardwoods	Cypress	Mangrove	Dry	Swamp	Dry	Wet	Fresh	Salt	Lakes	Ponds	Springs	Streams	Coastal		Man-Modified
Rock Dove	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U7-10
Band-tailed Pigeon	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Mourning Dove	P	U	U	A	A	U	U	U	-	U	-	-	C	-	A	-	-	-	-	-	-	-	-	-	C1-5,7,8
Ringed Turtle Dove**	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R7-10
Ground Dove	P	-	-	A	A	-	-	-	-	-	-	-	C	-	A	-	-	-	-	-	-	-	-	-	C3,5
exotic parrots**	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
exotic parrots**	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Canary-winged Parakeet**	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R8,9
Monk Parakeet**	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R8,9
Budgerigar**	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R8,9
Mangrove Cuckoo	S	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	
Yellow-billed Cuckoo	S	[illegible]	[illegible]	[illegible]	[illegible]	C	[illegible]	C	C	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	
Black-billed Cuckoo	M	[illegible]	[illegible]	[illegible]	[illegible]	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Smooth-billed Ani	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	
Groove-billed Ani	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	
Barn Owl	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	U7
Screech Owl	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	[illegible]	-	-	-	-	-	-	-	-	-	-	-	C1,2
Great Horned Owl	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	
(Florida) Burrowing Owl	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	U	-	-	-	-	-	-	-	-	-	U3-5
Barred Owl	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	
Short-eared Owl	W	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	R	R	-	-	-	-	-	-	R	-	R2-6
Chuck-will's-widow	S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	C	-	-	-	-	-	-	-	-	-	
Whip-poor-will	W	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	U	-	-	-	-	-	-	-	-	-	
Common Nighthawk***	S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	A	-	-	-	-	-	-	-	-	-	C2-10
Chimney Swift***	S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	C7-10
Ruby-throated Hummingbird	S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	U	-	-	-	-	-	-	-	-	-	-	-	U2,7-9
Rufous Hummingbird	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	
Belted Kingfisher	W	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	C	C	-	C	C	-	U	-	-	C11-13
Common Flicker	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	U	-	-	-	-	-	-	-	-	-	-	-	C1,2,7,8;U3-5
Pileated Woodpecker	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	
Red-bellied Woodpecker	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	C	-	-	-	-	-	-	-	-	-	-	-	C1,2,7,8
Red-headed Woodpecker	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	U2,7
Yellow-bellied Sapsucker	W	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	U	-	-	-	-	-	-	-	-	-	-	-	C1,2
Hairy Woodpecker	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	U	-	-	-	-	-	-	-	-	-	-	-	
Downy Woodpecker	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	C	-	-	-	-	-	-	-	-	-	-	-	C1,2
Red-cockaded Woodpecker	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	
Ivory-billed Woodpecker	P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	
Eastern Kingbird	S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	U	C	-	C	U	-	-	-	-	-	-	-	C2,3,7
Gray Kingbird	S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	C	-	-	-	-	-	-	-	-	-	-	C	-	
Western Kingbird	W	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	R	-	-	-	-	-	-	-	-	-	
Scissor-tailed Flycatcher	W	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	R	-	-	-	-	-	-	-	U	-	R3
Great Crested Flycatcher	S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	C2,7
Eastern Phoebe	W	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	U	-	C	C	-	U	C	-	-	-	-	C2,7
Yellow-bellied Flycatcher	M	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	R2
Acadian Flycatcher	S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	R	-	-	-	-	-	-	-	-	-	-	-	U2
Least Flycatcher	M	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	U2
Traill's Flycatcher****	M	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	U2
Olive-sided Flycatcher	M	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	R	-	-	R	-	-	-	-	-	-	-	R2
Eastern Wood Pewee	S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	R	-	-	-	-	-	-	-	-	-	-	-	U2
Vermilion Flycatcher	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	
Horned Lark	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	
Bahama Swallow	A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	
Tree Swallow***	W	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	A	A	A	-	A	A	-	A	-	-	A1-7,11-13
Bank Swallow***	M	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	U	U	-	U	U	-	U	-	-	U11,12
Rough-winged Swallow***	S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	U	U	-	U	U	-	U	-	-	U11,12
Barn Swallow***	M	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	U	U	U	-	U	U	-	U	-	-	U11,12

**Escapees observed in wild

***Occurs in open air over all types of terrain.

****Includes Alder and Willow Flycatchers

Table 5.3. (Page 7 of 9)

Species	Seasonal Status	Terrestrial and Wetland Types																	Aquatic Types						Man-Modified
		Forest and Woodlands											Nonforest/ Herbaceous						Fresh Water				Marine		
		Pine-Oak		Pine Flatwoods		Hammocks			Wetland				Brushland		Prairies		Marshes		Lakes	Ponds	Springs	Streams	Coastal	Offshore	
		Sand Hills	Scrub	Scrub	Typical	Cabbage Palm	Mesic	Live Oak	Bayhead	Mixed Hardwoods	Cypress	Mangrove	Dry	Swamp	Dry	Wet	Fresh	Salt							
BIRDS (CONTD)																									
Cliff Swallow***	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	-	U	U	-	U	-	-	U11,12
Purple Martin***	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	-	C	C	-	C	-	-	C7-9,11-12
Blue Jay	P	C	C	-	C	C	C	C	C	C	C	-	U	-	-	-	-	-	-	-	-	-	-	-	C1,2,7-9
(Florida) Scrub Jay	P	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Common Crow	P	C	C	C	C	C	C	C	C	C	C	-	C	C	C	U	U	-	-	-	-	-	U	-	C1-5,7,8
Fish Crow	P	U	U	U	U	U	U	U	U	U	U	C	U	U	U	U	U	C	-	-	-	-	A	-	U1-5,7,8
Carolina Chickadee	P	U	U	-	-	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	U2,7-9
Tufted Titmouse	P	U	U	-	-	C	C	C	C	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	U2,7-9
White-breasted Nuthatch	P	-	-	R	R	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Red-breasted Nuthatch	W	-	-	-	R	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Brown-headed Nuthatch	P	-	-	-	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Brown Creeper	W	-	-		R	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	R2
House Wren	W	U	U	-	U	U	U	U	U	U	U	-	U	U	-	-	-	-	-	-	-	-	-	-	U2
Winter Wren	W	R	R	R	R	R	R	R	R	R	R	-	R	R	-	-	-	-	-	-	-	-	-	-	
Bewick's Wren	W	R	R	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	R2,7,8
Carolina Wren	P	C	C	C	C	A	A	C	A	A	A	-	C	C	-	-	-	-	-	-	-	-	-	-	C2,7,8
Long-billed Marsh Wren	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	U	U	U	-	U	-	-	U16
(Marian's) Marsh Wren	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	R	-	R	-	-	
Short-billed Marsh Wren	W	-	-	-	-	-	-	-	-	-	-	-	-	-	U	U	U	-	-	-	-	-	-	-	U5
Mockingbird	P	A	A	A	A	C	C	C	C	C	C	-	C	C	A	C	-	-	-	-	-	-	-	-	A1,2,7-9
Gray Catbird	P	C	C	U	U	C	C	C	C	C	C	-	C	C	U	U	-	-	-	-	-	-	-	-	C2,7,8
Brown Thrasher	P	C	C	U	U	C	C	C	C	C	C	-	C	C	U	U	-	-	-	-	-	-	-	-	C2,7,8
American Robin	W	C	C	C	C	C	C	C	-	C	C	-	C	C	A	A	U	-	-	-	-	-	-	-	A1-5,7-9
Wood Thrush	W	U	U	R	R	U	U	U	U	U	U	-	R	-	-	-	-	-	-	-	-	-	-	-	U2
Hermit Thrush	W	U	U	R	R	U	U	U	U	U	U	-	R	-	-	-	-	-	-	-	-	-	-	-	U2
Swainson's Thrush	M	R	R	R	R	R	R	R	R	R	R	-	R	-	-	-	-	-	-	-	-	-	-	-	R2
Gray-cheeked Thrush	M	R	R	R	R	R	R	R	R	R	R	-	R	-	-	-	-	-	-	-	-	-	-	-	R2
Veery	M	R	R	R	R	R	R	R	R	R	R	-	R	-	-	-	-	-	-	-	-	-	-	-	R2
Eastern Bluebird	P	U	U	U	U	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	U2,7
Blue-gray Gnatcatcher	P	C	C	U	U	C	C	C	C	C	C	-	U	U	-	-	-	-	-	-	-	-	-	-	U1,2
Golden-crowned Kinglet	W	U	U	R	R	U	U	U	U	U	U	-	R	R	-	-	-	-	-	-	-	-	-	-	R1,2
Ruby-crowned Kinglet	W	C	C	U	U	C	C	C	C	C	C	-	U	U	-	-	-	-	-	-	-	-	-	-	U1,2
Water Pipit	W	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	C	-	C	C	-	C	-	-	C3-6,11,12
Sprague's Pipit	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Cedar Waxwing	W	U	U	R	R	U	U	U	U	U	U	-	R	R	R	-	-	-	-	-	-	-	-	-	U1,2,7,8
Loggerhead Shrike	P	C	C	A	A	-	-	-	-	-	-	-	C	C	A	C	-	-	-	-	-	-	-	-	C2-5,7,8
Starling	P	U	U	U	U	U	U	U	U	U	U	-	U	U	U	-	-	-	-	-	-	-	-	-	U1-6;A7-10
White-eyed Vireo	P	C	C	C	U	C	C	C	C	C	C	-	C	C	U	-	-	-	-	-	-	-	-	-	C2
Bell's Vireo	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Yellow-throated Vireo	M	-	-	-	-	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	
Solitary Vireo	W	U	U	U	U	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	U2
Black-whiskered Vireo	S	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	
Red-eyed Vireo	S	-	-	-	-	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	U2
Philadelphia Vireo	M	-	-	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	R2
Warbling Vireo	M	-	-	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	R2
Black-and-white-Warbler	W	U	U	U	C	C	C	C	C	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	C2
Prothonotary Warbler	S	-	-	-	-	-	-	-	-	U	U	-	-	U	-	-	-	-	-	-	-	-	-	-	
Swainson's Warbler	M	-	-	-	-	-	-	-	-	R	R	-	-	R	-	-	-	-	-	-	-	-	-	-	
Worm-eating Warbler	M	-	-	-	-	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Bachman's Warbler	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Golden-winged Warbler	M	-	-	-	-	R	R	R	R	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	R5
Blue-winged Warbler	M	-	-	-	-	R	R	R	R	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	R5
(Lawrence's Warbler)	M	-	-	-	-	R	R	R	R	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	R5
(Brewster's Warbler)	M	-	-	-	-	R	R	R	R	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	R5
Tennessee Warbler	M	-	-	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Orange-crowned Warbler	W	U	U	-	-	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	U2
Nashville Warbler	M	-	-	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Northern Parula	P	U	U	-	U	C	C	C	C	C	C	U	-	-	-	-	-	-	-	-	-	-	-	-	C2
Yellow Warbler	M	U	U	-	-	U	U	U	U	U	U	-	R	R	-	-	-	-	-	-	-	-	-	-	U2,7,8
Magnolia Warbler	M	R	R	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	R2
Cape May Warbler	M	-	-	-	-	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	U2
Black-throated Blue Warbler	M	U	U	-	-	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	
Yellow-rumped Warbler	W	A	A	C	C	A	A	A	A	A	A	-	C	C	-	-	-	-	-	-	-	-	-	-	A1-5,7,8
Black-throated Gray Warbler	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

*** Occurs in open air over all types of terrain

Table 5.3. (Page 8 of 9)

		Terrestrial and Wetland Types																	Aquatic Types						Man-Modified
		Forest and Woodlands											Nonforest/ Herbaceous						Fresh Water				Marine		
		Pine-Oak		Pine Flatwoods		Hammocks			Wetland				Brushland		Prairies		Marshes		Lakes	Ponds	Springs	Streams	Coastal		
	Seasonal Status	Sand Hills	Scrub	Scrub	Typical	Cabbage Palm	Mesic	Live Oak	Bayhead	Mixed Hardwoods	Cypress	Mangrove	Dry	Swamp	Dry	Wet	Fresh	Salt							
Black-throated Green Warbler	M	U	U	U	U	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	
Cerulean Warbler	M	-	-	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Blackburnian Warbler	M	R	R	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Yellow-throated Warbler	P	U	U	U	U	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	
Chestnut-sided Warbler	M	R	R	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Bay-breasted Warbler	M	R	R	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Blackpoll Warbler	M	-	-	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Kirtland's Warbler	M	-	-	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
(Sutton's Warbler)	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Pine Warbler	P	U	U	C	C	R	R	R	R	R	U	-	-	-	-	-	-	-	-	-	-	-	-	-	
Prairie Warbler	W	-	-	-	-	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	
(Florida) Prairie Warbler	P	-	-	-	-	-	-	R	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	
Palm Warbler	W	A	A	A	A	C	C	C	C	C	C	C	C	-	A	-	-	-	-	-	-	-	-	-	C1,7;A3-5
Ovenbird	W	-	-	-	-	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	
Northern Waterthrush	M	-	-	-	-	-	-	-	-	R	R	-	-	R	-	-	-	-	R	R	-	R	-	-	
Louisiana Waterthrush	M	-	-	-	-	-	-	-	-	R	R	-	-	R	-	-	-	-	R	R	-	R	-	-	
Kentucky Warbler	M	-	-	-	-	R	R	R	R	R	R	-	-	R	-	-	-	-	-	-	-	-	-	-	
Connecticut Warbler	M	-	-	-	-	R	R	R	R	R	R	-	-	R	-	-	-	-	-	-	-	-	-	-	
Mourning Warbler	M	-	-	-	-	R	R	R	R	R	R	-	-	R	-	-	-	-	-	-	-	-	-	-	
Common Yellowthroat	P	C	C	C	C	C	C	C	C	C	C	-	-	C	-	C	U	-	C	C	-	C	-	-	C11,12,18
Yellow-breasted Chat	M	-	-	-	-	R	R	R	R	R	R	-	R	R	-	-	-	-	-	-	-	-	-	-	
Hooded Warbler	M	-	-	-	-	U	U	U	U	U	U	-	-	U	-	-	-	-	-	-	-	-	-	-	
Wilson's Warbler	M	-	-	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
Canada Warbler	M	-	-	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	
American Redstart	M	-	-	-	-	C	C	C	C	C	C	-	U	U	-	-	-	-	[illegible]	[illegible]	-	[illegible]	-	-	C2
House Sparrow	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A1,2,7-10
Bobolink	M	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	C4-5
Eastern Meadowlark	P	U	U	A	A	-	-	-	-	-	-	-	-	-	A	U	-	-	-	-	-	-	-	-	A3-5,11
Western Meadowlark	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Yellow-headed Blackbird	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Red-winged Blackbird	P	U	U	U	U	-	-	-	U	U	U	-	U	C	U	A	A	-	[illegible]	[illegible]	-	[illegible]	-	-	A1-5,11,17,18
Orchard Oriole	S	-	-	-	-	R	R	R	-	R	-	-	-	-	-	R	R	-	-	-	-	-	-	-	R1,2,7,8
Spotted-breasted Oriole**	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Northern Oriole	W	-	-	-	-	R	R	R	-	R	-	-	-	-	-	R	R	-	-	-	-	-	-	-	R1,2,3,8
Rusty Blackbird	W	-	-	-	-	U	U	U	-	U	U	-	-	U	U	-	-	-	-	-	-	-	-	-	U2-5,18
Brewer's Blackbird	W	-	-	-	-	R	R	R	-	R	R	-	-	R	R	-	-	-	-	-	-	-	-	-	R2-5,18
Boat-tailed Grackle	P	-	-	-	-	-	-	-	-	-	-	-	U	A	U	A	A	-	A	A	-	-	-	-	A11,12,18
Common Grackle	P	-	-	-	-	-	-	-	U	U	U	-	U	U	U	U	U	-	[illegible]	[illegible]	-	-	-	-	C2-5,7-8
Brown-headed Cowbird	W	-	-	-	-	U	U	U	-	U	U	-	-	U	U	U	U	-	-	-	-	-	-	-	U2-5,7-8
Bronzed Cowbird	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Blue-gray Tanager	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Western Tanager	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Scarlet Tanager	M	-	-	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	R2
Summer Tanager	S	R	R	U	U	U	U	U	U	U	U	-	-	-	-	-	-	-	-	-	-	-	-	-	U2
Cardinal	P	C	C	R	R	C	C	C	C	C	C	-	U	U	-	-	-	-	-	-	-	-	-	-	C1,2,7-8
Rose-breasted Grosbeak	M	-	-	-	-	R	R	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	R2
Black-headed Grosbeak	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Blue Grosbeak	M	U	U	-	-	U	U	U	U	U	R	-	-	R	-	-	-	-	-	-	-	-	-	-	U2,7,8
Indigo Bunting	W	U	U	U	-	-	-	-	-	-	-	-	U	-	U	-	-	-	-	-	-	-	-	-	U8
Painted Bunting	M	-	-	R	R	-	-	-	-	-	-	-	R	-	R	-	-	-	-	-	-	-	-	-	R8
Dickcissel	W	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	U1,5,7,8
Evening Grosbeak	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R1-8
Purple Finch	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Pine Siskin	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R1,3-8
American Goldfinch	W	U	U	U	U	C	C	C	C	C	-	-	-	C	C	U	-	-	-	-	-	-	-	-	C1-5,7,8
Rufous-sided Towhee	P	A	A	A	A	C	C	C	C	C	C	-	A	U	A	U	-	-	-	-	-	-	-	-	A2,5-8
Savannah Sparrow	W	U	U	C	C	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	C2-5
Grasshopper Sparrow	W	-	-	-	-	-	-	-	-	-	-	-	-	-	U	-	-	-	-	-	-	-	-	-	U5,8
(Florida) Grasshopper Sparrow	P	-	-	R	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	R5
Henslow's Sparrow	W	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	R5,8
Le Conte's Sparrow	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Sharp-tailed Sparrow	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	
(Scott's) Seaside Sparrow	P	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	R	-	-	-	-	-	-	
Vesper Sparrow	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U1,3,4

Table 5.3. (Page 9 of 9)

Species	Seasonal Status	Terrestrial and Wetland Types																	Aquatic Types						Man-Modified
		Forest and Woodlands											Nonforest/ Herbaceous						Fresh Water				Marine		
		Pine-Oak		Pine Flatwoods		Hammocks			Wetland				Brushland		Prairies		Marshes		Lakes	Ponds	Springs	Streams	Coastal	Offshore	
		Sand Hills	Scrub	Scrub	Typical	Cabbage Palm	Mesic	Live Oak	Bayhead	Mixed Hardwoods	Cypress	Mangrove	Dry	Swamp	Dry	Wet	Fresh	Salt							
BIRDS (CONTD)																									
Lark Sparrow	W	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	R1,5
Bachman's Sparrow	P	—	—	U	U	—	—	—	—	—	—	—	—	—	U	—	—	—	—	—	—	—	—	—	R5
Dark-eyed Junco	W	R	R	R	R	R	R	R	—	R	—	—	R	—	—	—	—	—	—	—	—	—	—	—	U1,5,7,8
Chipping Sparrow	W	C	C	C	C	U	U	U	U	U	U	—	C	—	—	—	—	—	—	—	—	—	—	—	U1,5
Clay-colored Sparrow	A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Field Sparrow	W	U	U	U	U	R	R	R	R	R	R	—	U	—	—	—	—	—	—	—	—	—	—	—	R2,5,7,8
White-crowned Sparrow	W	R	R	R	R	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	R2,5,7,8
White-throated Sparrow	W	R	R	R	R	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	R2,5
Fox Sparrow	W	R	R	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	
Lincoln's Sparrow	A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	U	U	—	—	—	—	—	—	—	C18
Swamp Sparrow	W	—	—	—	—	—	—	—	—	—	—	—	R	—	R	—	—	—	—	—	—	—	—	—	R2,5
Song Sparrow	W	R	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Lapland Longspur	A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Snow Bunting	A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
MAMMALS																									
Opossum		U	C	A	A	C	A	C	U	A	C	U	U	U	C	C	C	—	—	—	—	—	C	—	C1-7,5,8
Southeastern Shrew		—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Short-tailed shrew		—	—	—	—	—	U	—	—	U	U	—	—	—	—	U	—	—	—	—	—	—	—	—	
Least Shrew		U	C	U	R	—	—	—	—	R	—	—	—	—	U	—	—	—	—	—	—	—	—	—	U1-3,5-9
Eastern Mole		—	—	—	U	—	—	—	—	C	—	—	—	—	U	—	—	—	—	—	—	—	—	—	
Southeastern Myotis		—	—	—	U	—	—	C	—	U	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Eastern Pipistrelle		—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Big Brown Bat		—	—	—	U	U	—	U	—	U	U	—	—	—	—	—	—	—	—	—	—	—	—	—	
Red Bat		—	—	—	R	—	R	—	—	R	R	—	—	—	—	R	R	—	—	—	—	—	—	—	
Seminole Bat		—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Hoary Bat		—	—	—	—	—	—	—	—	U	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Northern Yellow Bat		—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Evening Bat		—	—	—	U	—	—	—	—	—	—	—	—	—	—	R	R	—	—	—	—	—	—	—	
Eastern Big-eared Bat		—	—	—	R	—	R	—	—	R	R	—	—	—	—	—	—	—	—	—	—	—	—	—	
Mexican Free-tailed Bat		—	—	—	—	—	—	—	—	U	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C1-3,5-8
Nine-banded Armadillo		U	C	C	A	C	A	C	R	C	U	—	C	C	A	C	—	—	—	—	—	—	—	—	C18
Marsh Rabbit		—	—	—	U	—	U	—	—	C	U	—	U	C	U	A	C	—	—	—	—	—	—	—	C1-10,18
Eastern Cottontail Rabbit		U	U	C	A	C	U	U	—	U	U	—	C	U	A	A	U	—	—	—	—	—	—	—	
Black-tailed Jack Rabbit		—	X	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C1,7-9
Eastern Gray Squirrel		R	C	—	U	—	—	U	—	A	C	—	—	—	—	—	—	—	—	—	—	—	—	—	
Sherman's Fox Squirrel		U	U	—	U	—	—	R	—	U	R	—	—	—	—	—	—	—	—	—	—	—	—	—	
Southern Flying Squirrel		—	U	—	U	—	U	U	—	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	U1-3,5-6
Southeastern Pocket Gopher		R	—	—	R	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	U16
Rice Rat		—	—	—	R	—	R	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	
Eastern Harvest Mouse		—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Oldfield Mouse		U	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	U1
Cotton Mouse		U	A	A	U	U	U	U	—	A	U	—	—	—	—	—	—	—	—	—	—	—	—	—	
Florida Mouse		U	U	U	U	—	U	U	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Golden Mouse		—	—	—	U	—	R	—	—	U	U	—	—	—	—	—	—	—	—	—	—	—	—	—	U1,5,6
Hispid Cotton Rat		U	C	C	A	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Eastern Woodrat		—	—	—	—	—	U	—	—	U	U	—	—	—	—	—	—	—	—	—	—	—	—	—	
Round-tailed Muskrat		—	—	—	—	—	—	—	—	—	R	—	—	—	—	R	U	—	R	R	—	R	—	—	C9-10
Black Rat		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C9-10
Norway Rat		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C1-5,7-10
House Mouse		—	—	U	U	—	—	—	—	—	—	—	U	—	U	—	—	—	—	—	—	—	—	—	
Nutria		—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	R	—	R	R	—	—	—	—	
Bottle-nosed Dolphin		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	
Coyote		—	—	—	—	—	—	—	—	R	—	—	R	—	R	—	—	—	—	—	—	—	—	—	
Red Fox		—	—	—	R	—	—	—	—	R	—	—	R	—	R	R	—	—	—	—	—	—	—	—	U2,5,8
Gray Fox		—	U	C	C	—	U	U	—	R	R	—	—	—	C	C	—	—	—	—	—	—	—	—	
Florida Black Bear		R	R	R	R	—	—	—	—	R	R	—	—	—	R	—	—	—	—	—	—	—	—	—	C2
Raccoon		U	U	U	C	U	C	U	U	C	C	U	U	C	U	C	U	—	—	—	—	—	—	—	
Florida Long-tailed Weasel		—	—	—	R	—	U	—	—	U	U	—	—	—	—	U	—	—	—	—	—	—	—	—	
Florida Mink		—	—	—	—	—	—	—	—	—	R	—	—	—	—	R	R	—	R	R	R	R	—	—	C1-8
Eastern Spotted Skunk		R	U	U	C	—	—	—	—	—	—	C	C	—	C	—	—	—	—	—	—	—	—	—	U1-8
Striped Skunk		R	—	—	R	—	R	—	—	U	R	—	—	—	U	R	—	—	—	—	—	—	—	—	R16
River Otter		—	—	—	—	—	—	—	—	U	C	U	—	U	—	U	C	—	U	U	U	C	U	—	
Florida Panther		R	R	—	R	—	—	—	R	R	R	—	—	R	—	—	—	—	—	—	—	—	—	—	R2
Bobcat		R	R	R	C	U	U	U	R	U	U	—	U	U	U	U	—	—	—	—	—	—	—	—	
Jaguarundi		—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R15
Manatee		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	R	R	R	
White-tailed Deer		U	U	U	C	C	C	U	—	C	U	—	U	U	C	U	U	—	—	—	—	—	—	—	
Wild Hog		—	—	—	R	—	U	—	—	U	U	—	U	U	C	U	U	—	—	—	—	—	—	—	

In support of the federal law and its intent, the Florida Game and Fresh Water Fish Commission made a commitment on July 1, 1974, to protect threatened and endangered wildlife within the state (Frye 1974). Emanating from this commitment was a list of threatened and endangered vertebrates in Florida, some of which do not appear on the federal list (USDI 1974). Both the federal and state lists are updated and amended as necessary and new lists published periodically. Current federal actions and proposed actions pertaining to these species appear in the weekly Federal Register; those of the FGFWFC appear annually in Florida's Hunting and Fresh Water Fishing Regulations.

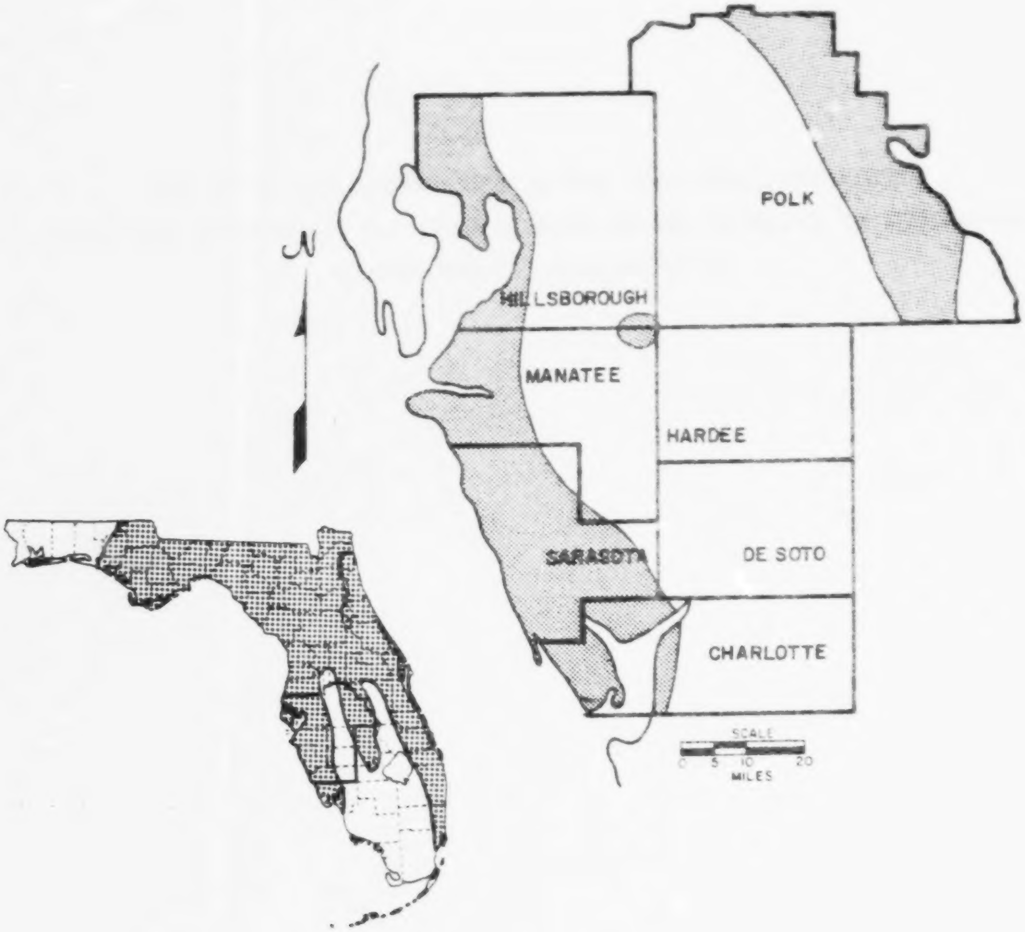
The following narrative treats each of the 41 threatened and endangered species on these two lists, discussing the species' range, habitat and population status in Florida and illustrating with maps its distribution within the study area and Florida range. Distribution within the study area generally reflects locality records, whereas the Florida range reflects the known geographic extent or presumed extent of the species in suitable habitat. Maps are not provided for species widely distributed over both the study area and state. A major portion of the data included in the narrative was derived from FCREPA's Inventory of Rare and Endangered Biota of Florida.

AMPHIBIANS, REPTILES, BIRDS, AND MAMMALS LISTED BY THE U.S. DEPARTMENT OF INTERIOR AND/OR FLORIDA GAME AND FRESH WATER FISH COMMISSION AS THREATENED AND ENDANGERED

- **Range:** The species as a whole occurs in the southeastern Coastal Plain to Texas and north from there to Indiana. This subspecies occurs in southern Georgia and in northern and central Florida. It is widespread in the northern part of the state and occurs in the study area along the coastal areas of Hillsborough, Manatee, Sarasota, and Charlotte counties as well as the Lake Wales Ridge of eastern Polk County.

- **Habitat:** Suitable habitat includes sandy ridges and xeric coastal areas. Either the blue jack-turkey oak or sand pine scrub association is optimum habitat; in particular, the habitat is usually a gopher tortoise burrow.

- **Status:** Diminishing habitat because of commercial or agricultural development has caused a decline of this subspecies, and recent studies indicate it to be uncommon in the 7-county area.



FLORIDA GOPHER FROG *(Rana areolata aesopus)*

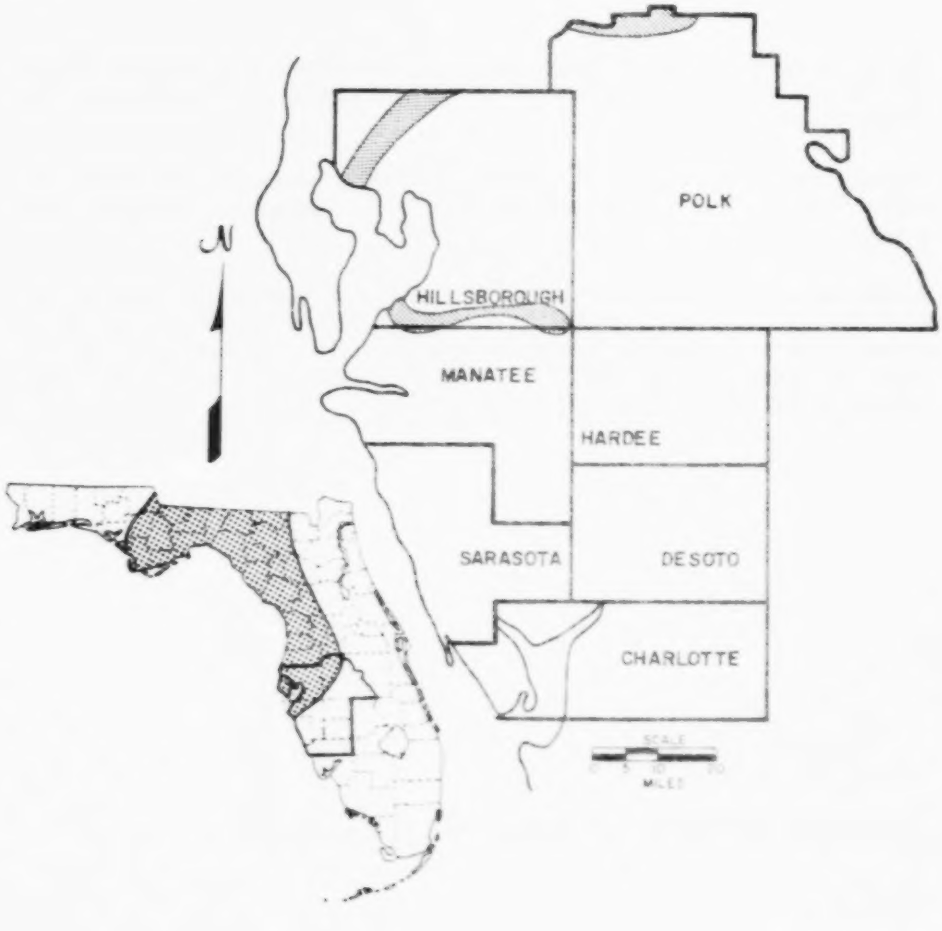
- **Range:** This reptile occurs throughout the southeastern Coastal Plain and is widely distributed over both the state of Florida and the study area.
- **Habitat:** Characteristically, alligators inhabit various wetlands and water bodies, including lakes, streams, marshes, swamps, and ponds.
- **Status:** Although the alligator presently is doing well in peninsular Florida and is even abundant in optimum habitat within the study area, its statewide future is questionable: poaching pressure and the public's general dislike or fear of the animal may reduce numbers.

AMERICAN ALLIGATOR *(Alligator mississipiensis)*

- **Range:** This species is found from Maryland south to central Florida and east to Texas.

- **Habitat:** In Florida, the subspecies occurs in certain rivers and spring runs that drain into the Gulf of Mexico, particularly streams with headwaters above 8 meters (26 feet). It reaches highest densities in areas heavy with *Naias* and *Sagittaria* including grassy mouths of river flats. The species apparently is quite tolerant to variations in salt concentrations. In the study area, the species has been found in the Withlacooche, Hillsborough, and Little Manatee rivers.

- **Status:** Degradation of coastal rivers and associated diminishing of suitable aquatic flora during the past decade have noticeably diminished observed cooter numbers. The species apparently is quite rare in the study area.

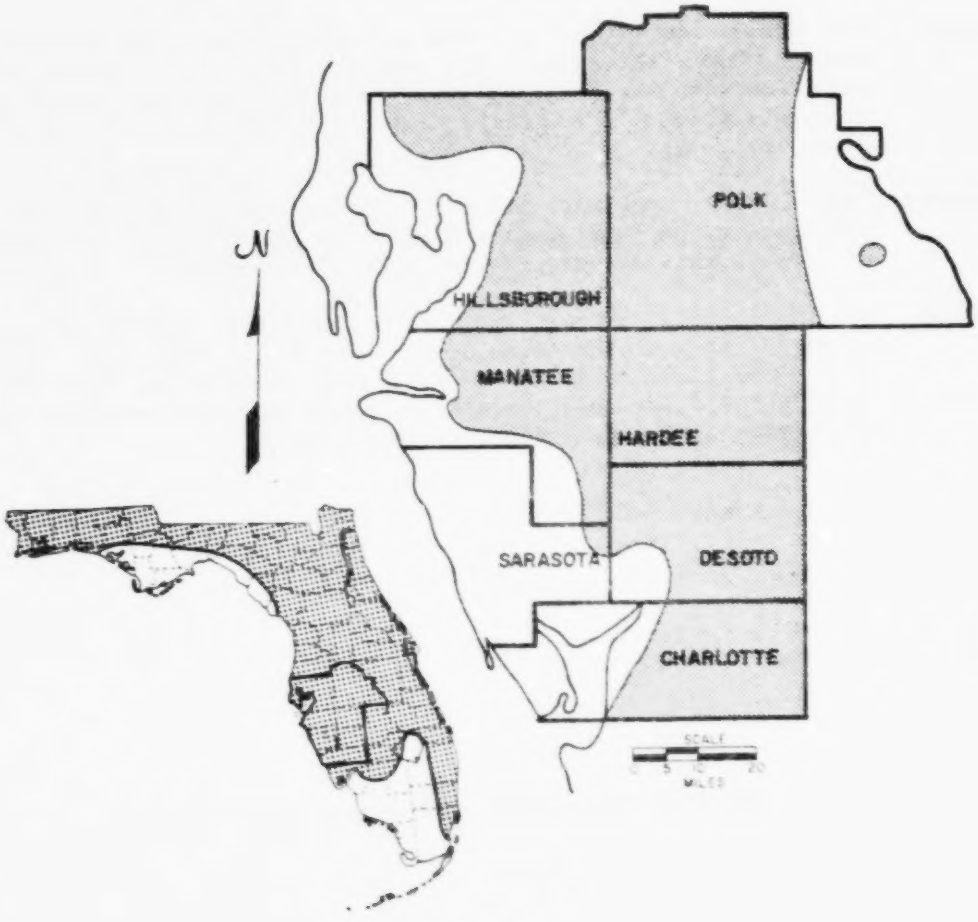


SUWANEE COOTER *(Chrysemys concinna suwanniensis)*

- **Range:** Relict populations occur in suitable habitat from the tip of the Florida peninsula to the level of Sarasota and Fort Lauderdale; from these points, distribution northward is wide and then in relict patches again eastward and westward along the southernmost Coastal Plain to Louisiana and South Carolina.

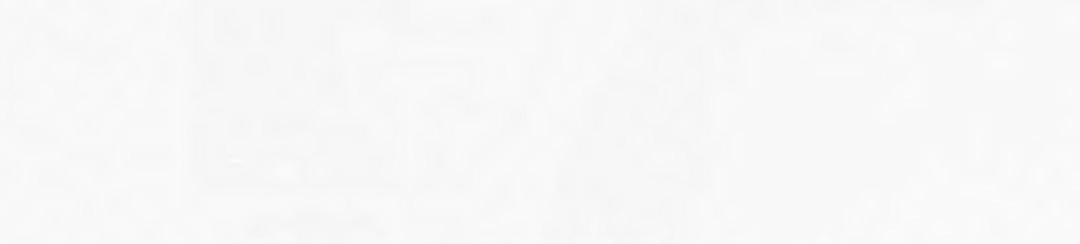
- **Habitat:** Well-drained soils are the major requisite. Among the prime habitats are such sandy habitats as sand pine scrub, longleaf pine/turkey oak, beach scrub, and live-oak hammock.

- **Status:** Within similar types of habitat in the study area, abundance varies from rare to abundant (Table 5.1), depending primarily on the quality and quantity of available habitat. Loss of habitat has been the primary factor in maintaining populations.



GOPHER TORTOISE (*Gopherus polyphemus*)

- **Range:** The green turtle, comprising several subspecies, occurs in marine waters throughout the world. The Florida population nests on the beaches of several islands along the central portion of the state's Atlantic coast and disperses on beaches along the coastline of the study area.
- **Habitat:** The highly migratory green turtle spends the majority of its time grazing on lush aquatic vegetation along shoals and lagoons of oceanic islands and off the continental shelf.
- **Status:** The flesh of the green turtle is the prime source of turtle steak and soup and has been highly sought in the past. Thus, researchers now consider the Florida population, once common along the Florida coastline, to be diminished and estimate that no more than 50 mature females are present.



ATLANTIC GREEN TURTLE (*Chelonia mydas mydas*)

- **Range:** This exclusively marine species is distributed worldwide including the entire coastline of Florida. Nesting in the state occurs principally on the Atlantic coast.

- **Habitat:** The species is most abundant in tropical and subtropical waters. More highly adapted to marine life than any other turtle, it spends most of its life in open water 30 to 50 meters (98 to 164 feet) deep. Rarely does it venture inland except to nest.

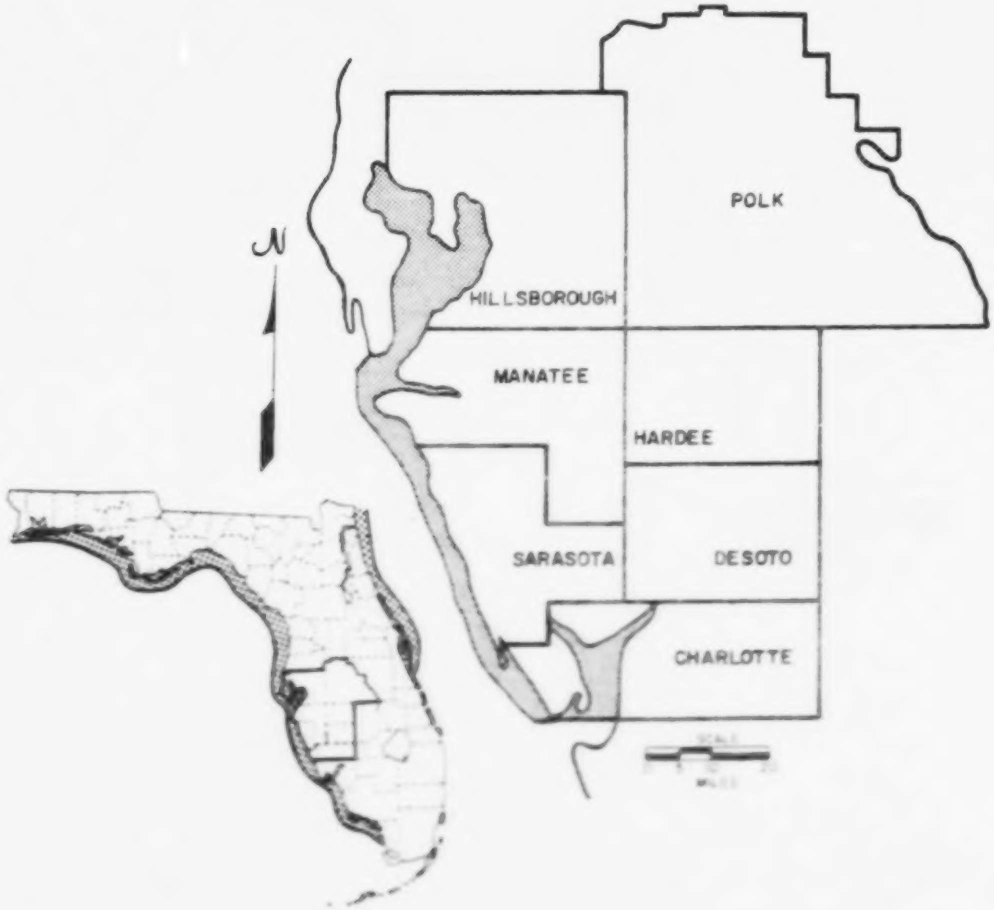
- **Status:** The USDI considers the leatherneck to be endangered because of sparse numbers along most of the Atlantic coastline. Even fewer numbers are found along Florida's coastline; however, there are no records indicating that the leatherneck was ever common along the Florida coastline.

ATLANTIC LEATHERNECK TURTLE *(Dermochelys coriacea)*

- **Range:** The loggerhead is cosmopolitan, occurring in temperate and subtropical seas. In the U.S., it nests from North Carolina through Florida along the Atlantic coast and, to a lesser extent, on the islands off the Gulf states.
- **Habitat:** Open seas are the primary habitat. Visits inland are rare except during the nesting season.
- **Status:** The U.S. population is estimated to be 25,000 to 50,000 individuals, of which approximately 90 percent nest in Florida. Erosion, beachfront development, and shrimping activities off nesting beaches apparently are causing an overall decrease in loggerhead population.

ATLANTIC LOGGERHEAD TURTLE (Caretta caretta)

- **Range:** Adults of this primarily marine species are found only in the Gulf of Mexico, but immature individuals range along the Atlantic United States except south Florida and infrequently along European shores. They nest only along a 16-kilometer (10-mile) stretch of Mexico.
- **Habitat:** The species occupies offshore marine waters during most of its life. Young turtles often occur in estuaries.
- **Status:** Florida's estuaries, especially in the Cedar Keys/Crystal River area, are important to young ridleys; within the study area's estuarine habitats, the species appears to be quite rare.

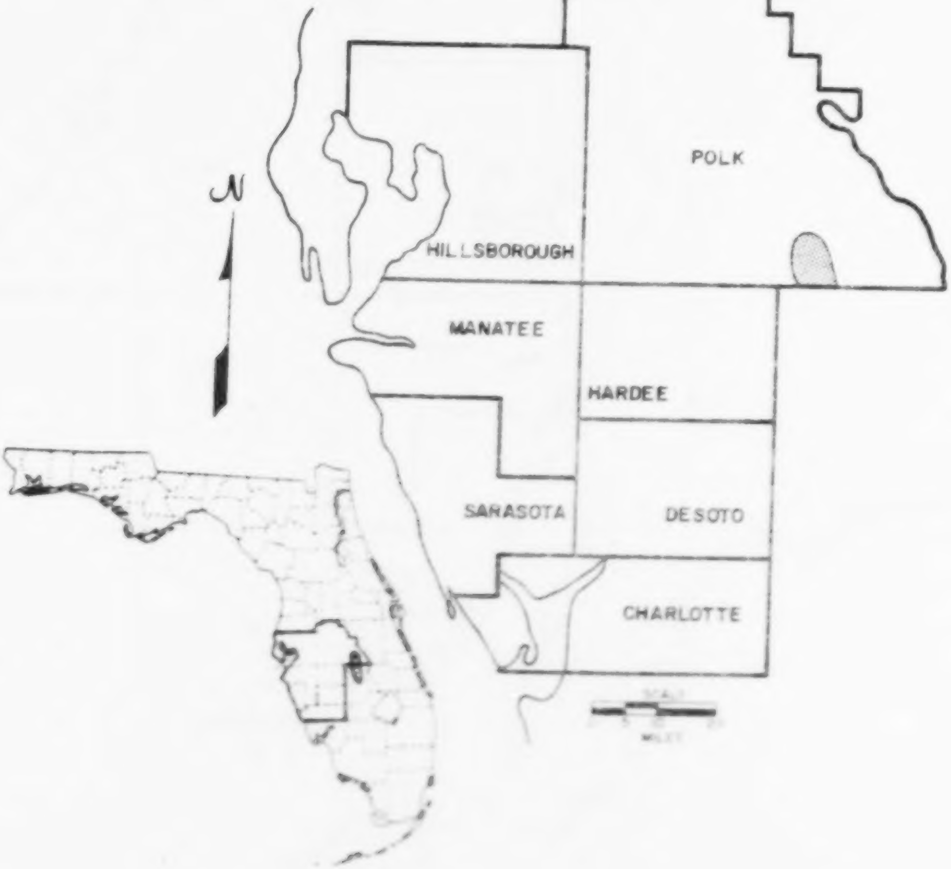


ATLANTIC RIDLEY TURTLE *(Lepidochelys kempi)*

- **Range:** The species as a whole occurs in the southeastern U.S., but this subspecies is found only on the Lake Wales Ridge in Polk and Highlands counties, Florida. It is known from comparatively few localities.

- **Habitat:** Sand pine scrub forests (rosemary scrub) are the major habitat of the skink, which burrows in the St. Lucie fine sand. Secondary habitats include successional scrub oak (turkey oak) areas that have replaced sandhill communities exploited for timber.

- **Status:** Recent and continued development on the Lake Wales Ridge, apparently the only area supporting this subspecies, is evoking concern.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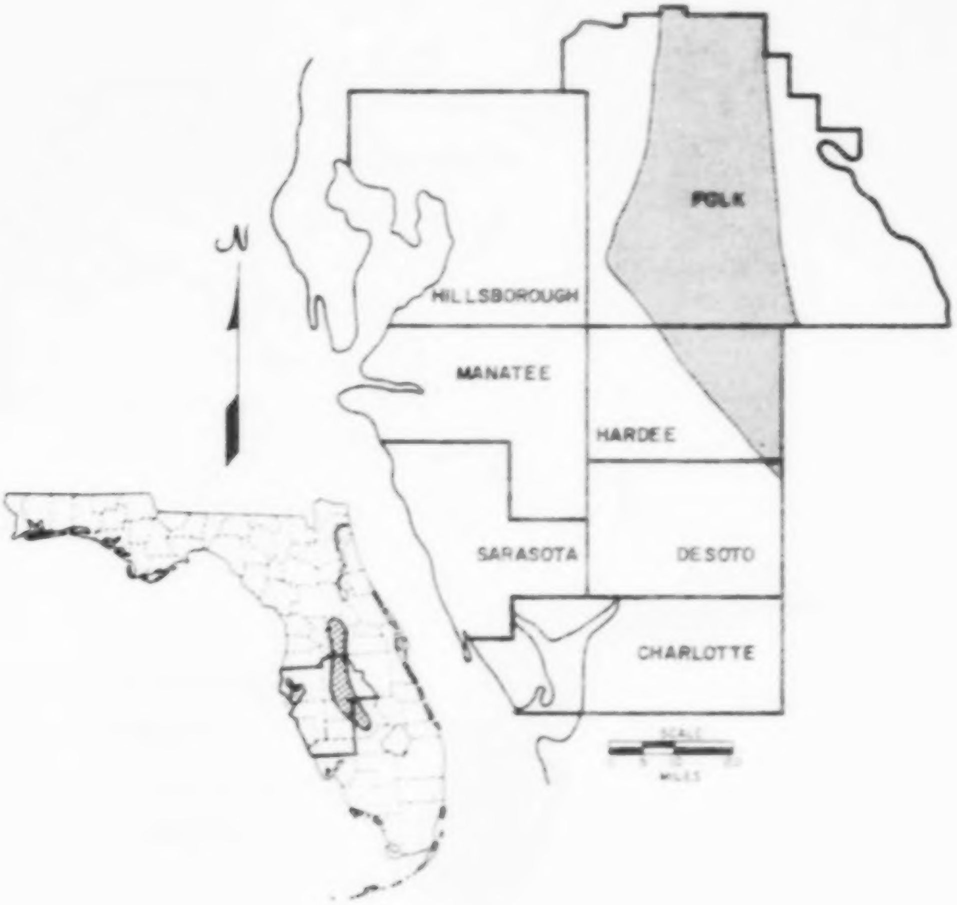
BLUE-TAILED MOLE SKINK *(Eumeces egregius lividus)*

- **Range:** This lizard is endemic to Florida and has been recorded in Highlands, Polk, Lake, and Marion counties.

- **Habitat:** The species is supported by sand pine and scrub forests of the Central Highlands. It makes its home on loosely packed sand at elevations of 27 meters (90 feet) or more and can be found directly under the surface of the St. Lucie fine sand generally beneath vegetative litter.

- **Status:** Although this small herptile is still common over much of its range, land development is fragmenting its habitat at a rapid pace, posing the greatest threat to its survival.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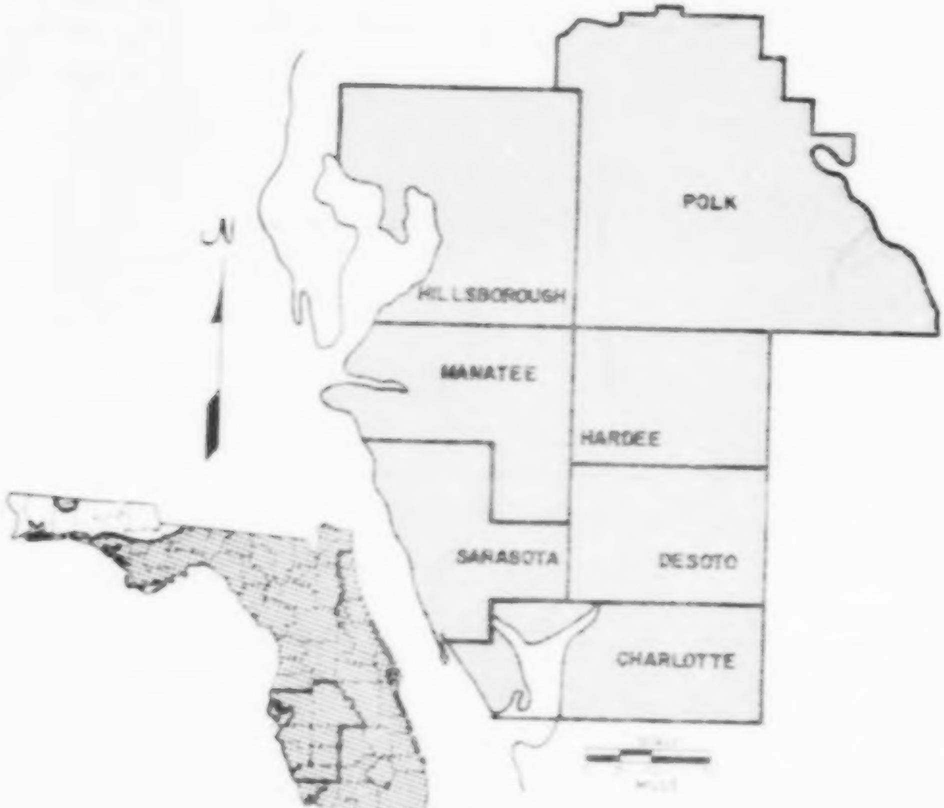
SAND SKINK (*Neoseps reynoldsi*)

- **Range:** The indigo occurs throughout the American tropics, with most of Florida and the southern peripheries of states from Georgia to Texas, and possibly South Carolina, representing the northern limits of its range.

- **Habitat:** General habitat requirements include dry sandy areas, but the species is not uncommon in adjacent moister habitats. Rarely is it associated with artificial habitats.

- **Status:** The indigo apparently is most abundant in typical pine flatwoods and mixed hardwood swamps. Its sporadic distribution and loss of habitats because of development have caused concern for this species in all areas in which it occurs. It is rare in the study area.

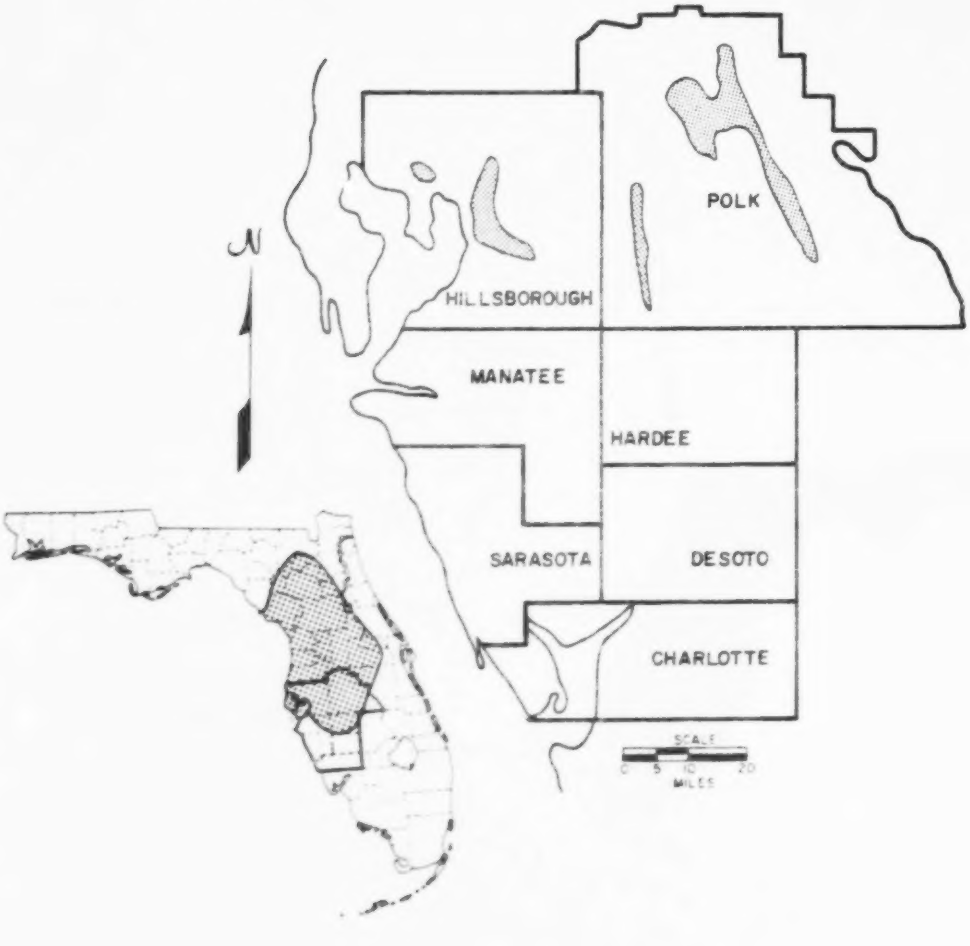


EASTERN INDIGO SNAKE (*Drymarchon corais*)

- **Range:** This species occurs only in peninsular Florida, particularly the more northern part. Within the study area, it has been found in a few locations in Hillsborough and Polk counties. A record from Highlands county represents the known southernmost distribution.

- **Habitat:** The species' primary habitat is the longleaf pine/turkey oak association, but individuals have been found also in adjacent upland hammocks and sand pine scrub.

- **Status:** Of most serious concern for the short-tailed snake's existence are its habitat requirements. Urban or other development on the well-drained soils in which it occurs is its most emminent threat. It apparently is rare in the 7-county study area.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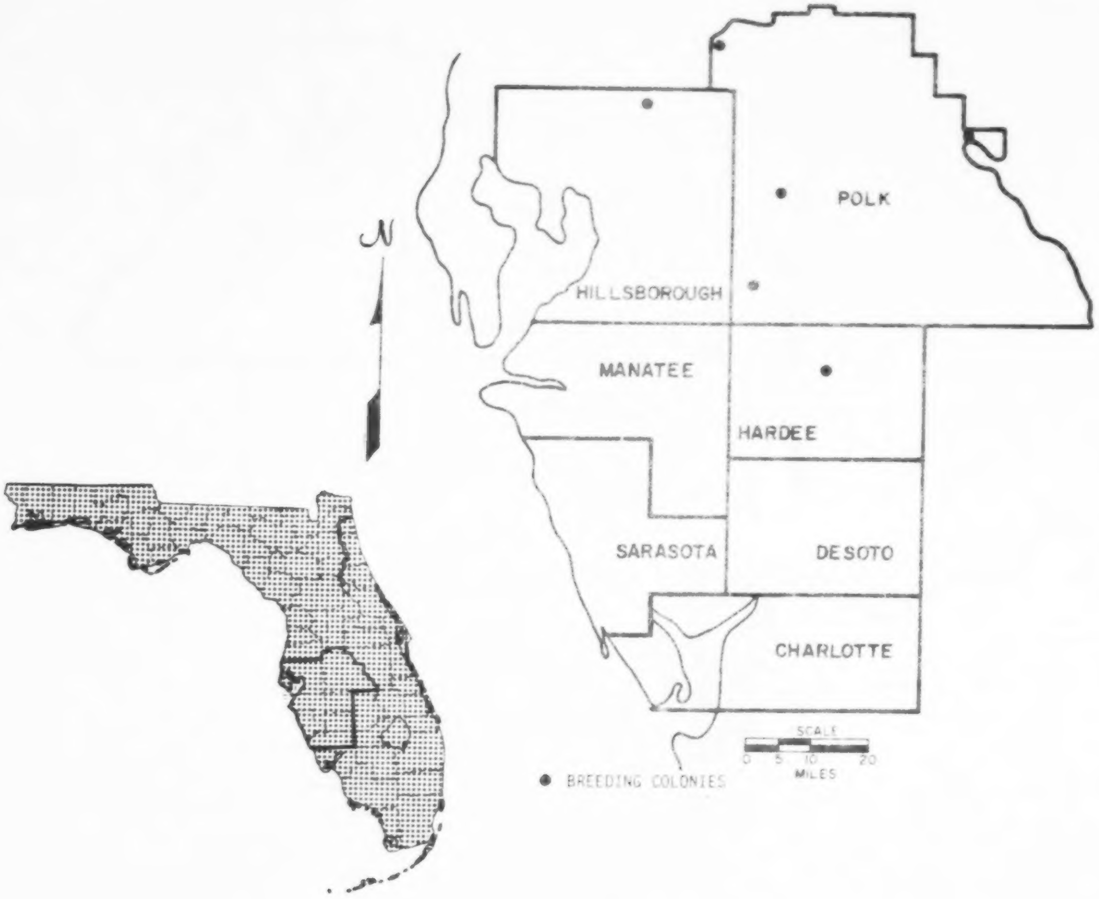
SHORT-TAILED SNAKE *(Stilosoma extenuatum)*

- **Range:** The species nests in some 20 peninsular Florida colonies and from Mexico south to northern Argentina, dispersing north up the Mississippi Valley to Arkansas and west Tennessee.
- **Habitat:** It inhabits marshes and other wetlands, both freshwater and brackish, feeding in altered habitats such as flooded pastures that become especially suitable when fish are concentrated in small pools as a result of drying. Several important rookeries are present in the 7-county study area.
- **Status:** The Wood Stork is considered by many conservationists as the most immediately endangered wading bird in Florida.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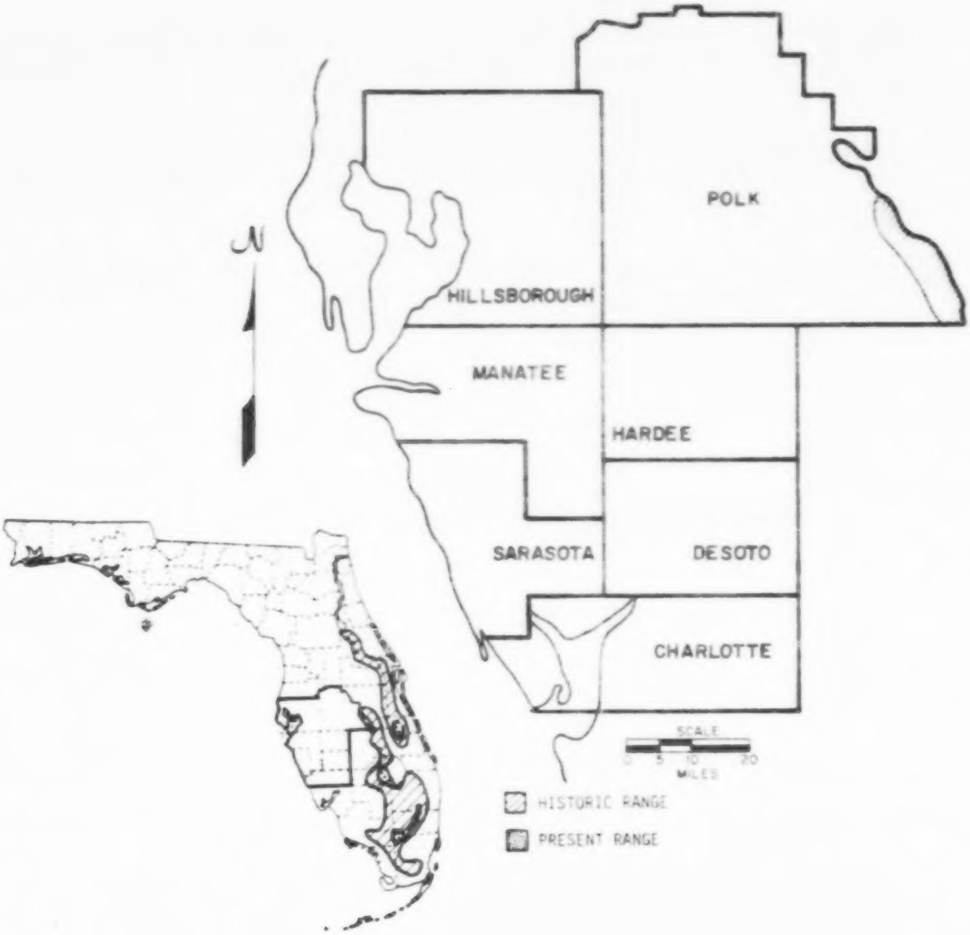
WOOD STORK *(Mycteria americana)*

- Range: The Everglade Kite is neotropical in distribution, with the Florida race presently restricted primarily to a few wetlands in southcentral Florida, none within the study area.
- Habitat: Kites require extensive freshwater marshes that retain some water during the entire year and prefer shallow marshes of less than 1 meter (3 feet) with scattered shrubs and small trees.
- Status: As recently as 1973, there were slightly more than 100 in the Florida population and the trend toward population decline has continued. Drainage of marsh areas, shooting, and aquatic weed control are among contributing factors.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FLORIDA EVERGLADE KITE *(Rostrhamus sociabilis plumbeus)*

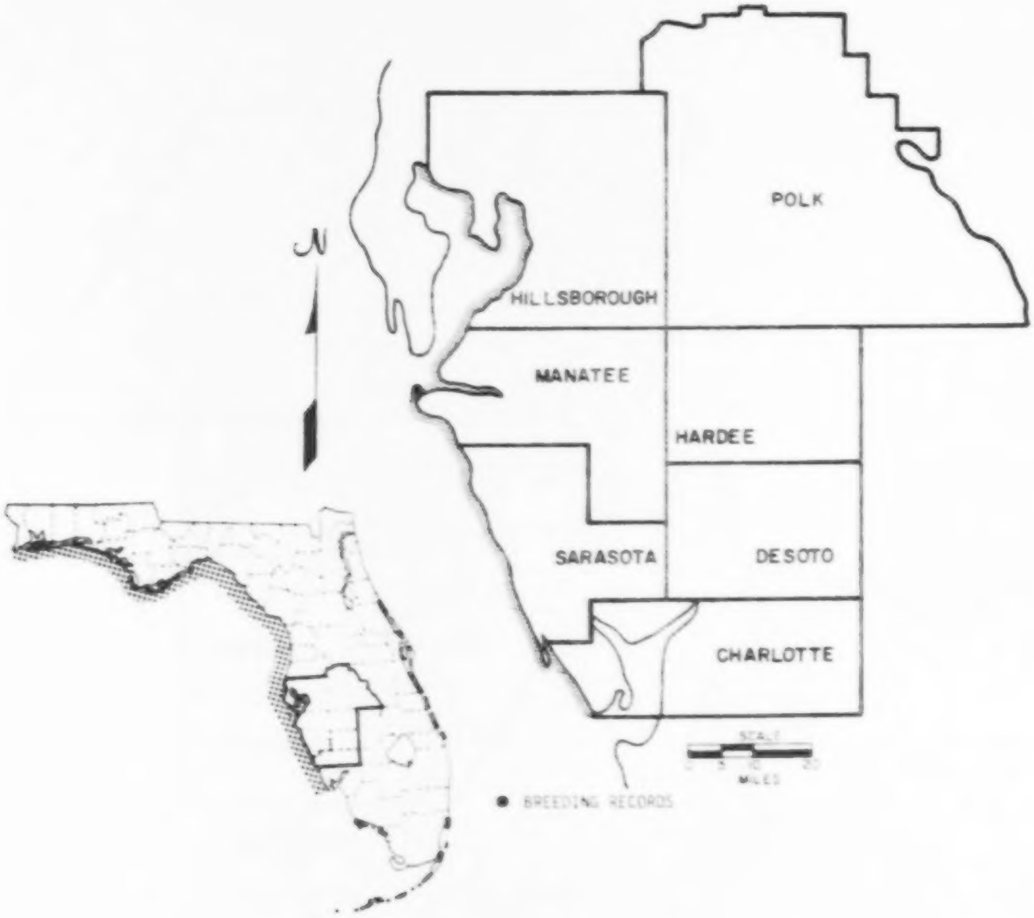
- **Range:** This species is cosmopolitan, occurring on all continents except Antarctica. It apparently does not breed in Florida, although it winters over the entire state.
- **Habitat:** Winter habitat in Florida optimally comprises coastal areas with adequate perching sites and a generous supply of small birds for food.
- **Status:** All Peregrine Falcon populations have declined drastically in past years because of harmful pesticides. Peregrine Falcons are observed only rarely in the study area.

PEREGRINE FALCON *(Falco peregrinus)*

- **Range:** This subspecies comprises an eastern population that breeds along the coast of the Gulf of Mexico and, where there is suitable habitat, among the Caribbean Islands. A western population ranges along the West Coast of the U.S. south to the Baja Peninsula and occurs in inland patches in suitable habitat as far east as the Texas/Oklahoma Panhandle.

- **Habitat:** Nesting is exclusively on expansive dry sandy beaches, and feeding is generally along tidal flats.

- **Status:** Because secluded dry-beach habitats have been developed, the Snowy Plover's numbers in Florida have declined. It is rare along the coastal parts of the study area.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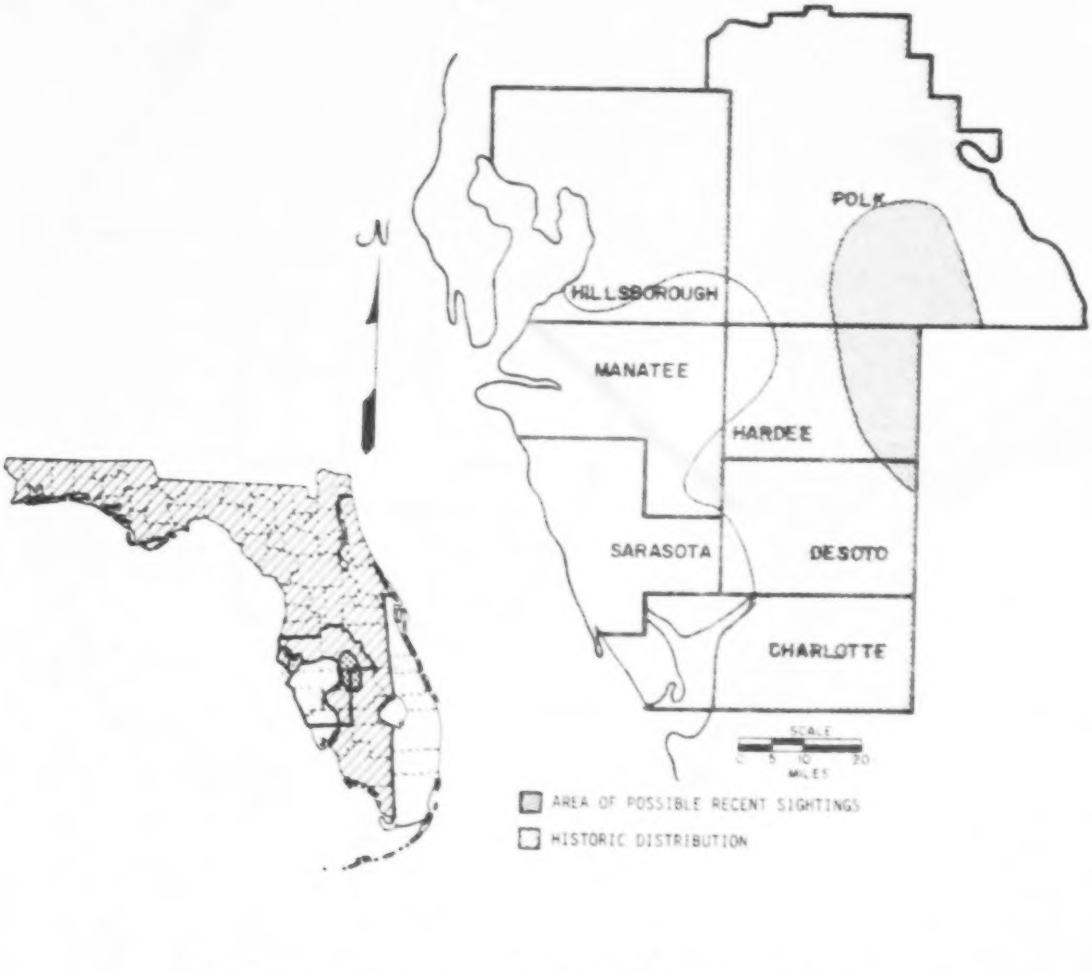
SNOWY PLOVER (*Charadrius alexandrinus tenuirostris*)

- **Range:** The Ivory-billed Woodpecker's present range is unknown and it may be extinct. In the past, it occurred in the south Atlantic and Gulf states north to Missouri, southern Illinois, and Indiana.
- **Habitat:** Typically, this species occupied swamp forests of the southeastern states, preferring dead cypress trees.
- **Status:** This species is believed to have disappeared from most of Florida by the early 1900s and from all of the state by 1940. One of the last reported sightings (in 1937) was from Highlands Hammock State Park immediately east of the study area in west-central Florida.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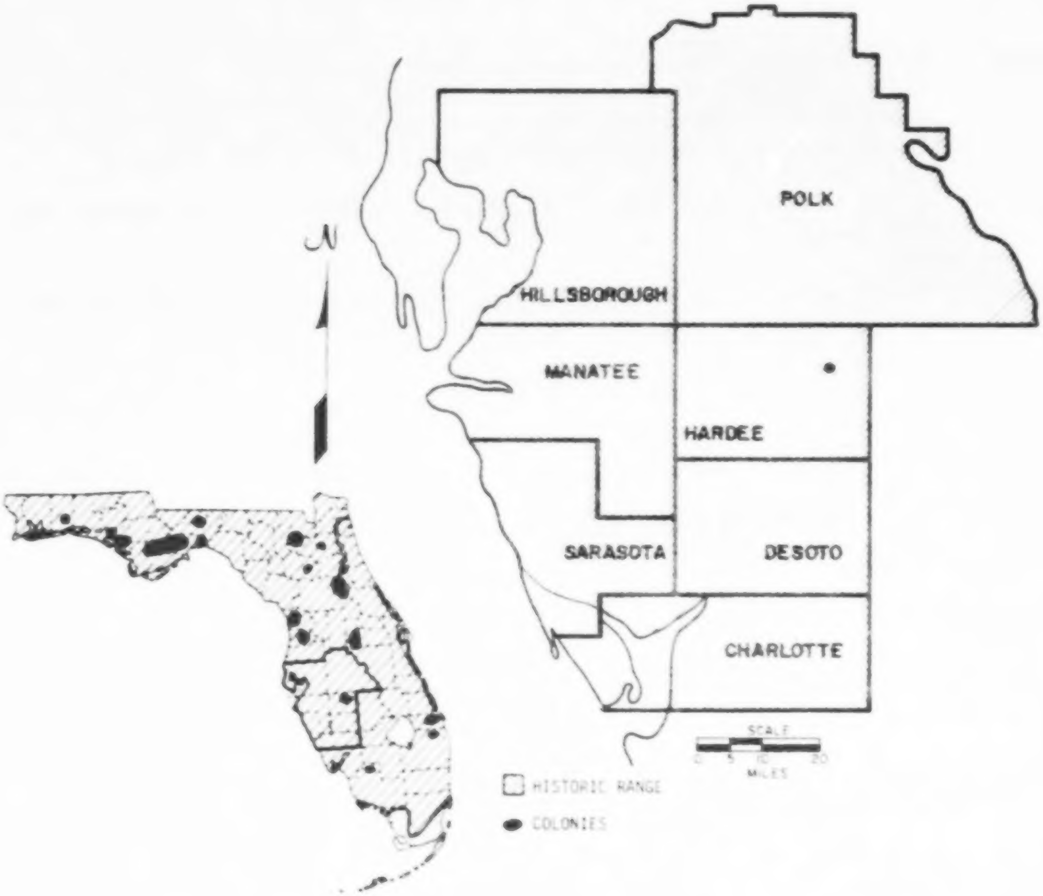
IVORY-BILLED WOODPECKER (*Campephilus principalis*)

- Range: This species is endemic to the southeastern United States and is now quite local, although its present range is much the same as its historic range.
- Habitat: Primarily a species of the southern pine forest, the Red-cockaded Woodpecker favors a habitat of large open pine stands. Large dead or dying trees are essential for nesting.
- Status: Timber-cutting practices in past years have selected against this species. It is considered rare in the few areas it still inhabits in Florida.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RED-COCKADED WOODPECKER *(Picoides borealis)*

- Range: This warbler formerly ranged over most of the southeastern United States into Arkansas and Missouri and was known to breed only in Florida, Cuba, and the Isle of Pines. It presently is local at best over the central part of the former range.
- Habitat: River bottoms and lowland swamps are considered good habitat for the species.
- Status: The status is questionable; most authorities consider the species to be near extinction, if not already extinct.

BACHMAN'S WARBLER *(Vermivora bachmani)*

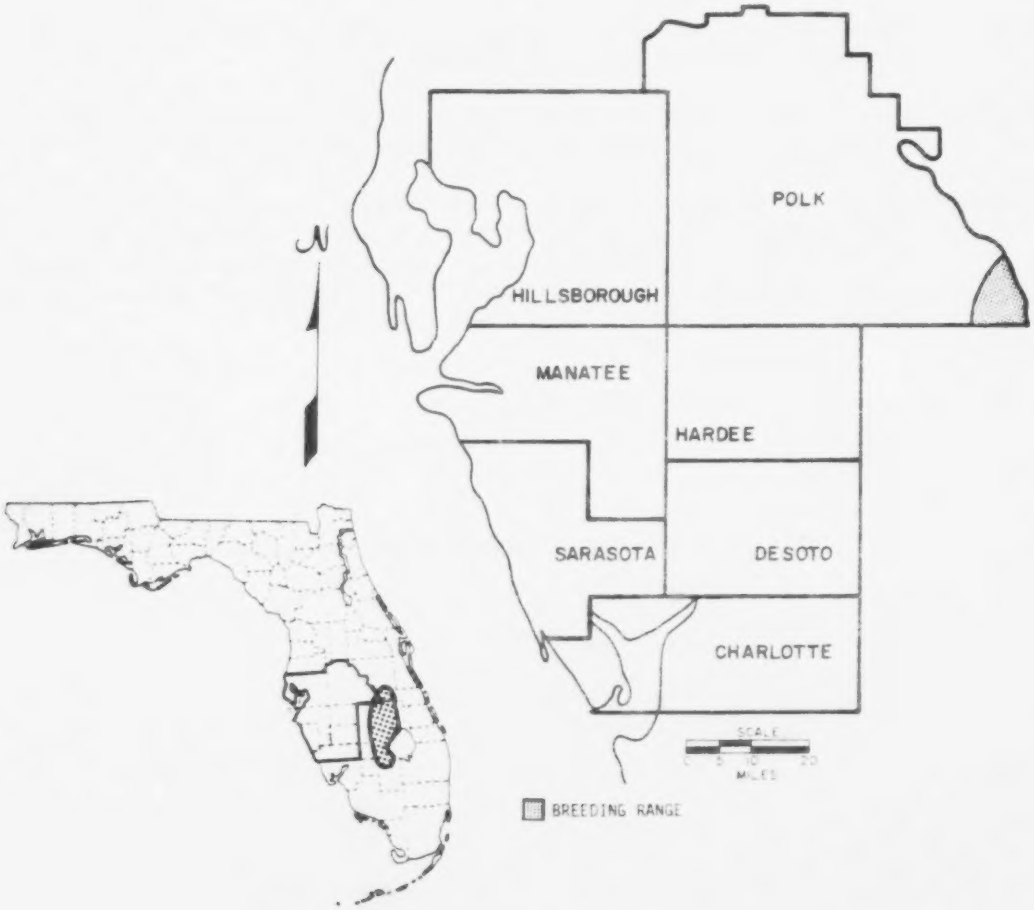
- Range: This species breeds only in Michigan and winters in the Bahamas, including Florida on its migratory route.
- Habitat: Kirtland's Warblers breed only in groves of jack pine but are found in a veriety of forest habitats during migration.
- Status: Species that have breeding ranges as limited as that of Kirtland's Warbler rarely maintain a large population, with the loss of breeding habitat drastically reducing overall population. Kirtland's Warbler numbers have declined primarily because of depletion of breeding habitat.

KIRTLAND'S WARBLER *(Dendroica kirtlandii)*

- Range: The breeding range of this Florida subspecies is restricted primarily to a small area in southcentral Florida, which extends only slightly into the 7-county study area. The species as a whole ranges over most of the U.S. and southern Canada.

- Habitat: The typical habitat of this species includes areas containing low cover (e.g., pastures, meadows, and dry prairies). The nest is generally built near the ground in grasses or similar plants.

- Status: The Grasshopper Sparrow apparently has never been abundant in Florida, and its numbers possibly declined recently. Data needed to determine its present status are lacking.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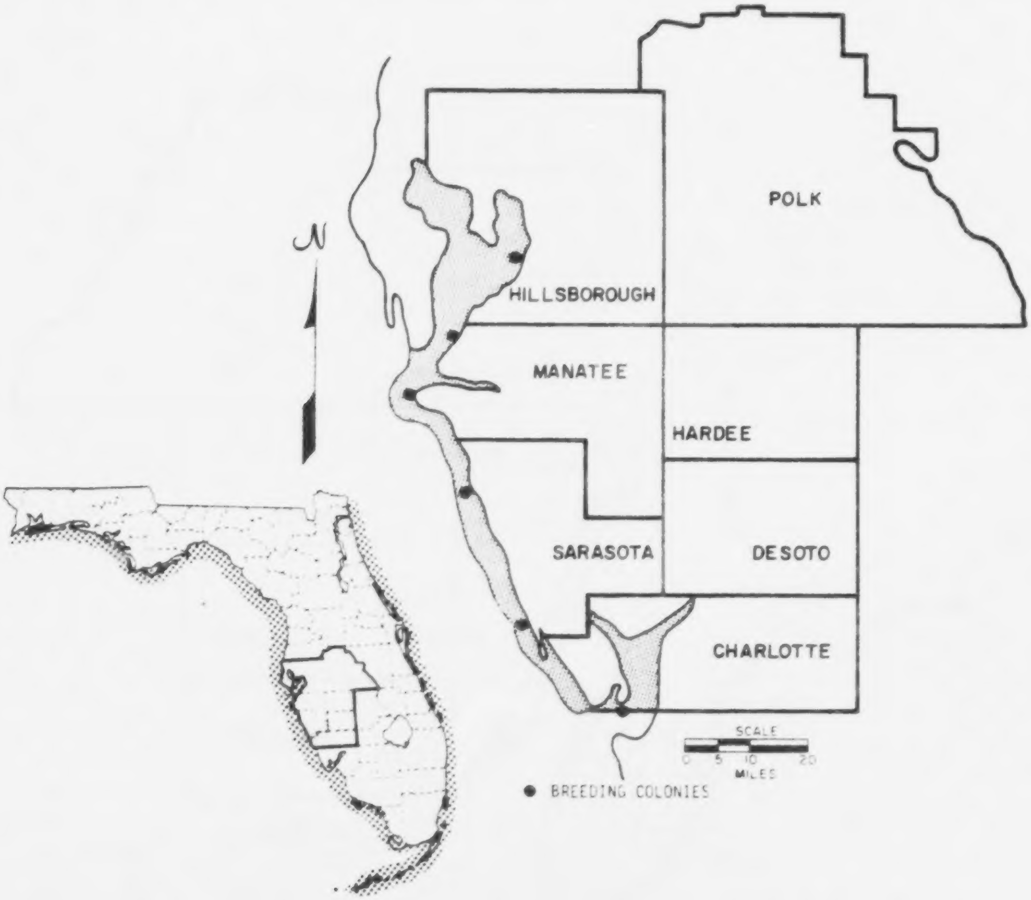
FLORIDA GRASSHOPPER SPARROW (*Ammodramus savannarum floridanus*)

- Range: This species ranges from British Columbia to southern Chile in the west and from North Carolina to northern South America in the east.

- Habitat: The Brown Pelican is strictly marine, preferring the shallow, clear water of bays, islands, and inlets.

- Status: Currently, the Florida population apparently is the most stable in the U.S., breeding along the east and west coasts of the peninsula and through the Keys. Approximately 4000 nests occur along the coastal part of the study area. Of prime concern is loss of numbers in California, Texas, and Louisiana.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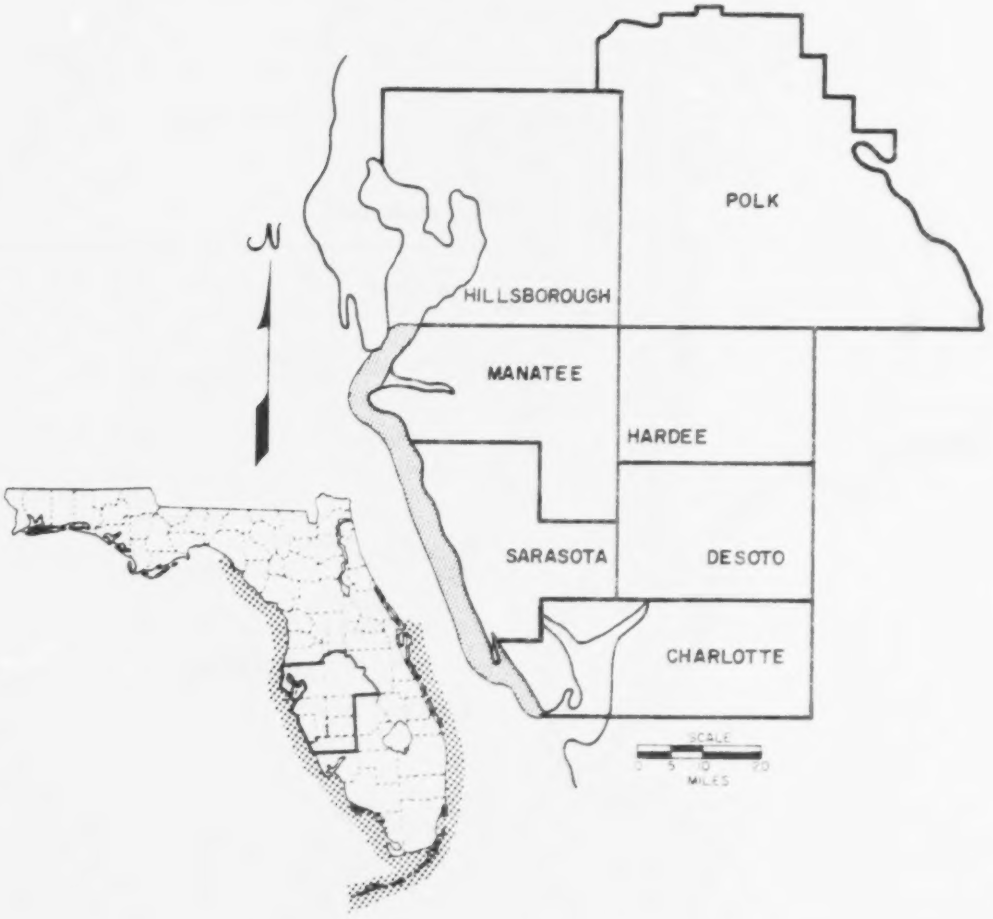
BROWN PELICAN *(Pelicanus occidentalis)*

- Range: This species' range comprises tropical and subtropical coasts of the eastern Pacific, Caribbean, and western Atlantic. A disjunct population is associated with the northeastern coast of Africa.
- Habitat: Roosting and nesting are in the tropics, primarily on offshore islands. The only breeding colony in Florida is at the tip of the Keys, but the species occurs regularly near the subtropical Florida coast in summer, occasionally flying inland along larger streams; summering birds are regularly sighted along the coastal part of the study area. During feeding periods, the Magnificent Frigatebird stays near shore, often following fishing boats.
- Status: Human encroachment of the breeding areas is the major survival pressure on the bird.

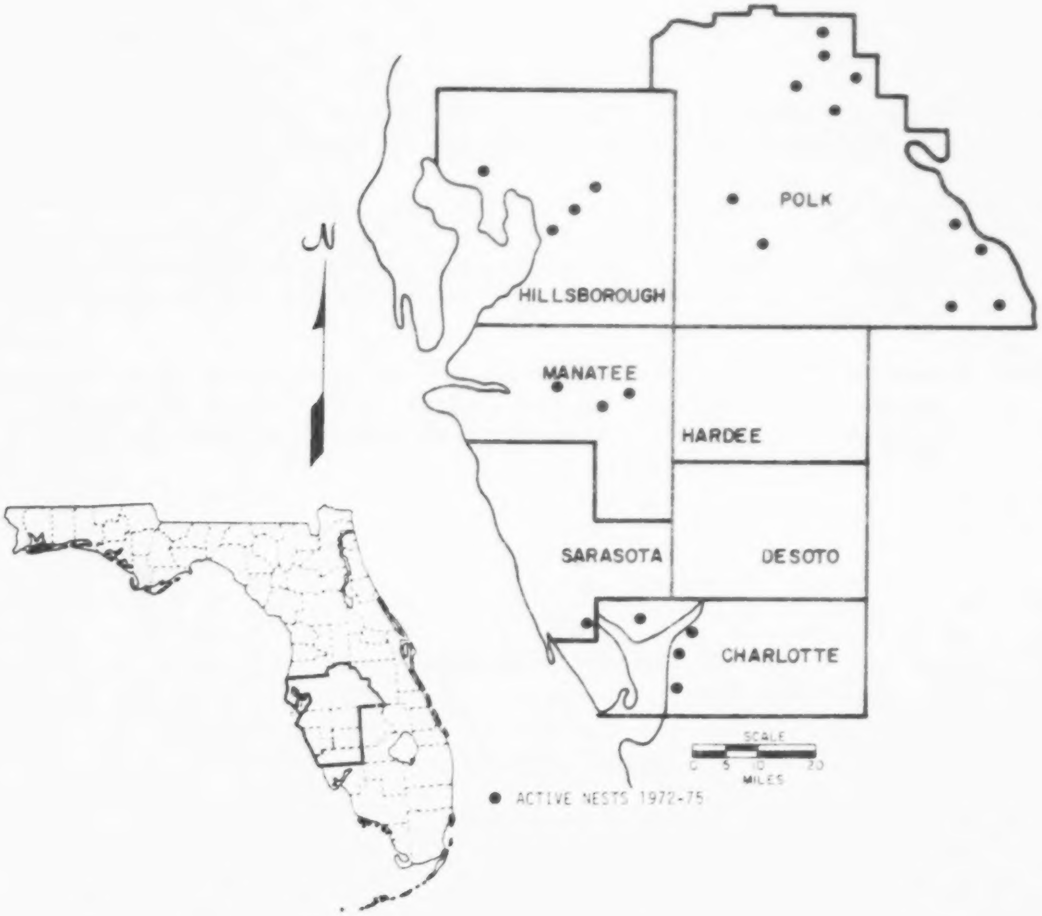


MAGNIFICENT FRIGATEBIRD *(Fregata magnificens)*

- **Range:** The former range of this subspecies was transcontinental, including most of the southern United States. The present range is difficult to discern since breeding with the northern subspecies is common.

- **Habitat:** The Bald Eagle is almost always associated with habitat near large streams, lakes, seashores, and other large water bodies.

- **Status:** Most of the remaining Southern Bald Eagle population nests in Florida, with a considerable number nesting in the study area. Development in coastal areas is considered one of the major pressures on the Florida nesting sites.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SOUTHERN BALD EAGLE *(Haliaectus l. leucocephalus)*

- **Range:** Except for polar regions, the Osprey is cosmopolitan, with Florida being the only state where it occurs year-round.
- **Habitat:** Riparian habitat is a necessity for the Osprey, as it is for the Bald Eagle. Seldom is this species encountered far from large bodies of water. The Osprey usually nests in large trees but occasionally uses man-made structures such as telephone poles and signal towers.
- **Status:** Most of the remaining nesting areas in Florida are within protected lands (national and state parks, etc.). Land development in recent years has destroyed nesting habitat, posing the greatest threat to the Osprey.

OSPREY *(Pandion haliaetus)*

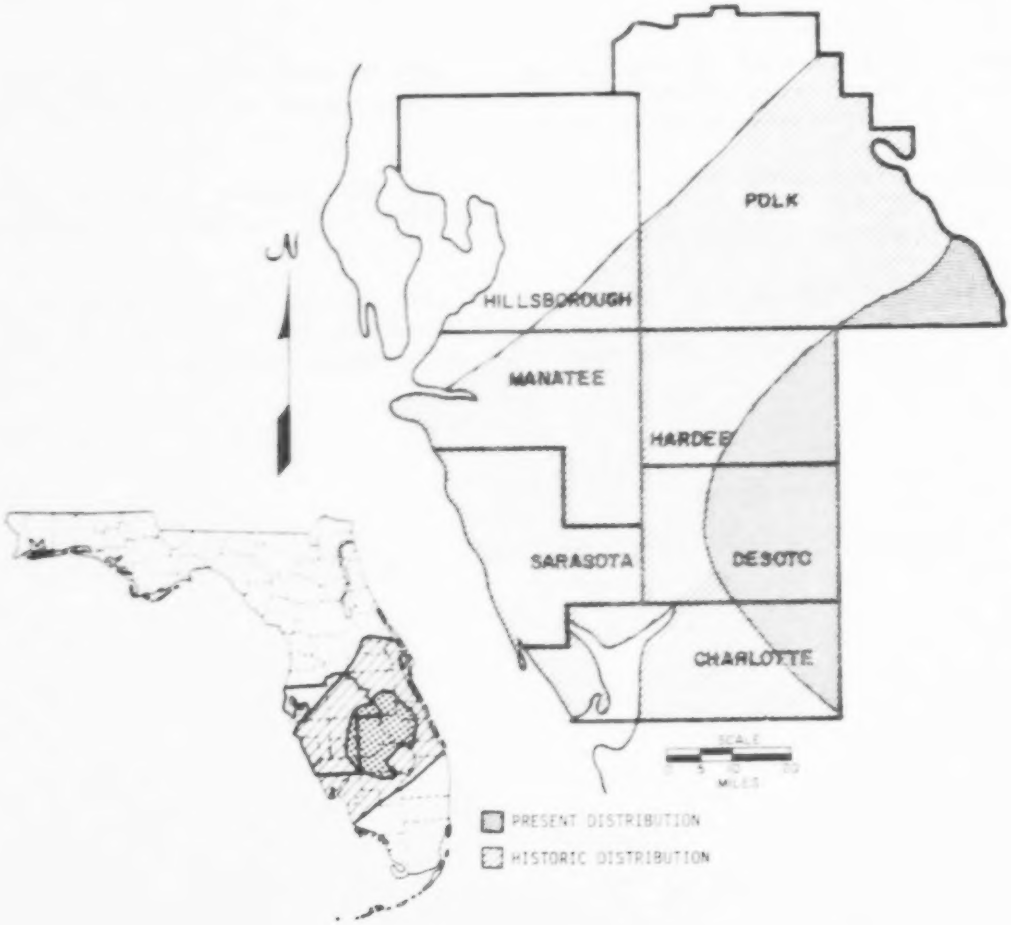
- **Range:** The Kestrel occurs throughout most of North and South America. The Florida subspecies is the only segment of the population that breeds in the southern U.S.
- **Habitat:** The Kestrel typically resides in open woods, pastures, old fields, and prairies. Telephone lines overlooking open habitat provide an optimum perch.
- **Status:** The apparent and unexplained recent decline in the Florida race has prompted this species' threatened status. The Kestrel appears to be locally common in the 7-county study area.

SOUTHEASTERN AMERICAN KESTREL *(Falco sparverius paulus)*

- **Range:** This species occurs locally from Florida, South Texas, and Arizona to Panama. In Florida, it is restricted to the southcentral part of the state, with the major concentration north and west of Lake Okeechobee.

- **Habitat:** Dry prairies and other low growth habitats appear to be most suitable for the Caracara, although it does occur with less frequency in a variety of less open habitats.

- **Status:** Preliminary results of a continuing study indicate that the Caracara population in Florida is less than 200 individuals; the eastern edge of the study area harbors a sizeable portion of this remaining population.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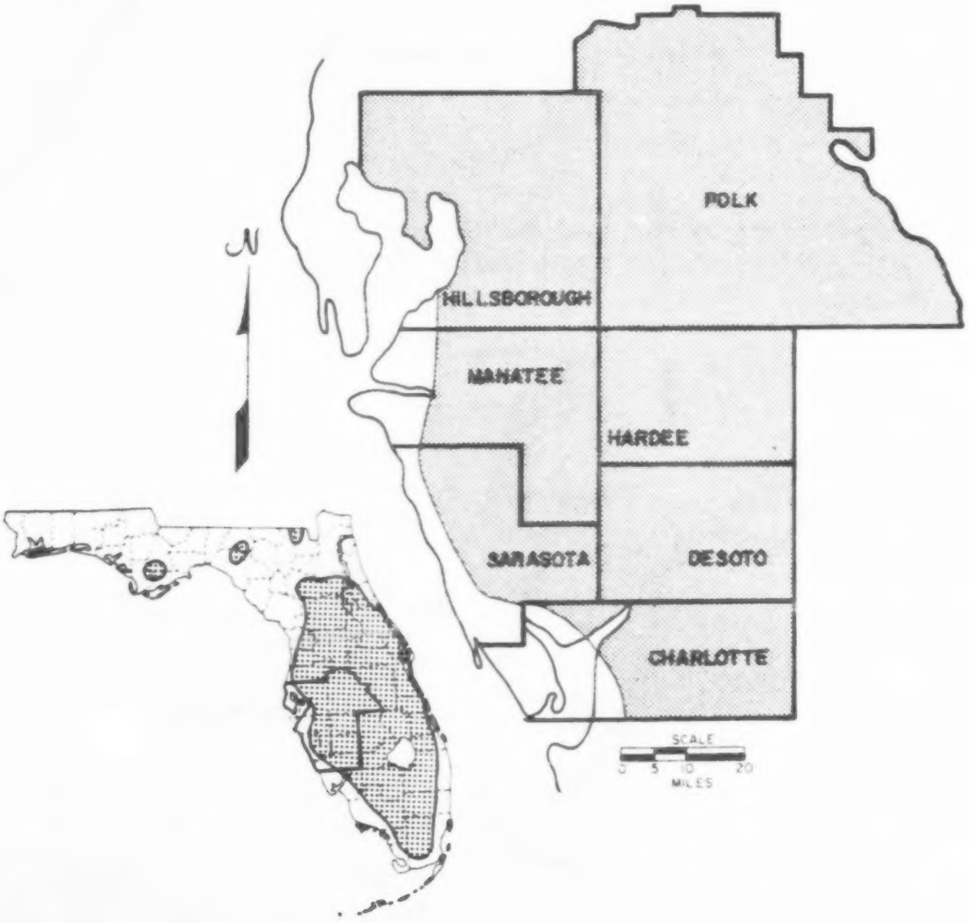
CARACARA *(Caracara cheriway)*

- Range: The Florida subspecies is a nonmigratory resident of peninsular Florida; it occurs in suitable habitat through most of interior peninsular Florida. There are local populations in the panhandle and the Okefenokee Swamp of Georgia.

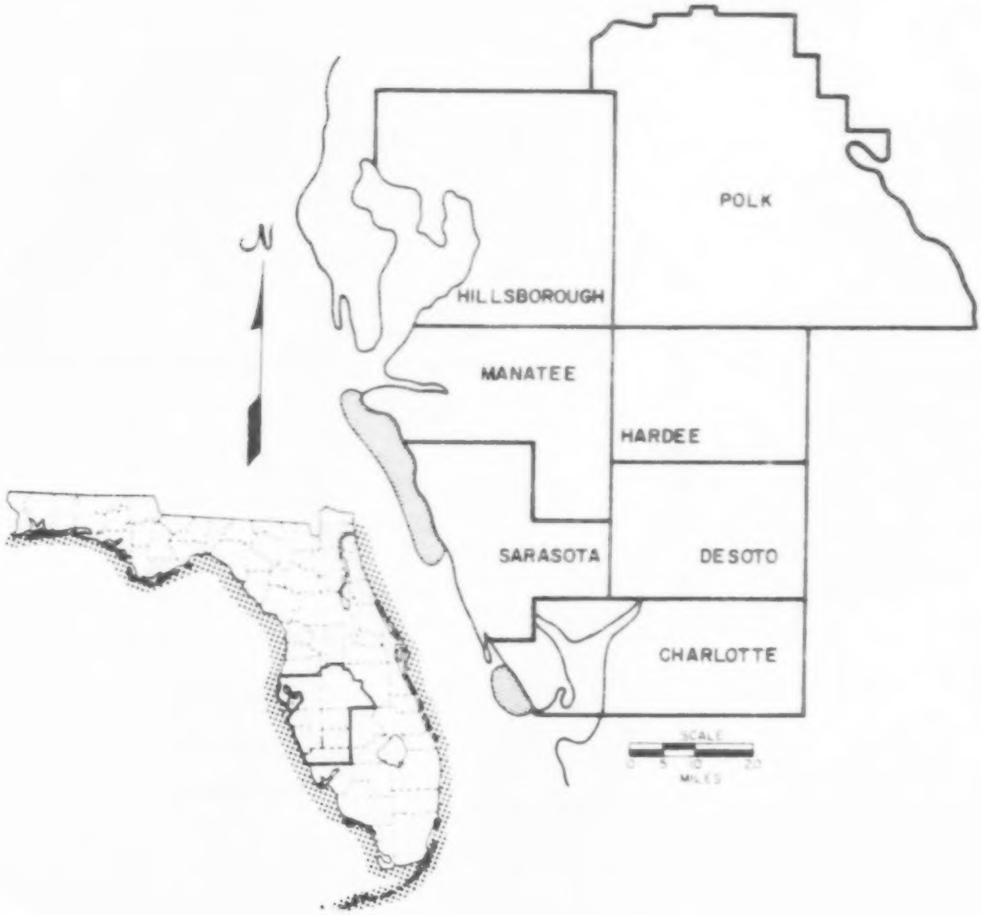
- Habitat: This is predominantly a species of the open wet prairie, preferring low-lying pastures, lake borders, and shallow marshes. Nests are normally constructed in shallow marshes.

- Status: Most authorities believe the Sandhill Crane has been undergoing a slow decline in recent years, but there are no data to support this assumption. An assumed reason for this decline is the draining and conversion of marshes into pasture. The Sandhill is generally uncommon in the 7-county study area.



FLORIDA SANDHILL CRANE *(Grus canadensis pratensis)*

- **Range:** The eastern subspecies breeds from Long Island to the Gulf of Mexico and farther south to northeastern South America; the western subspecies occurs from the Baja Coast to Chile.
- **Habitat:** Practically all types of marine coasts, tidal marshes, dredged spoils, and beaches are utilized by the Oystercatcher.
- **Status:** Although a resident of Florida, the species is rare in most areas and occurs along the coast of the study area in patchy distribution. Development on coastal beaches is a major factor in its decline.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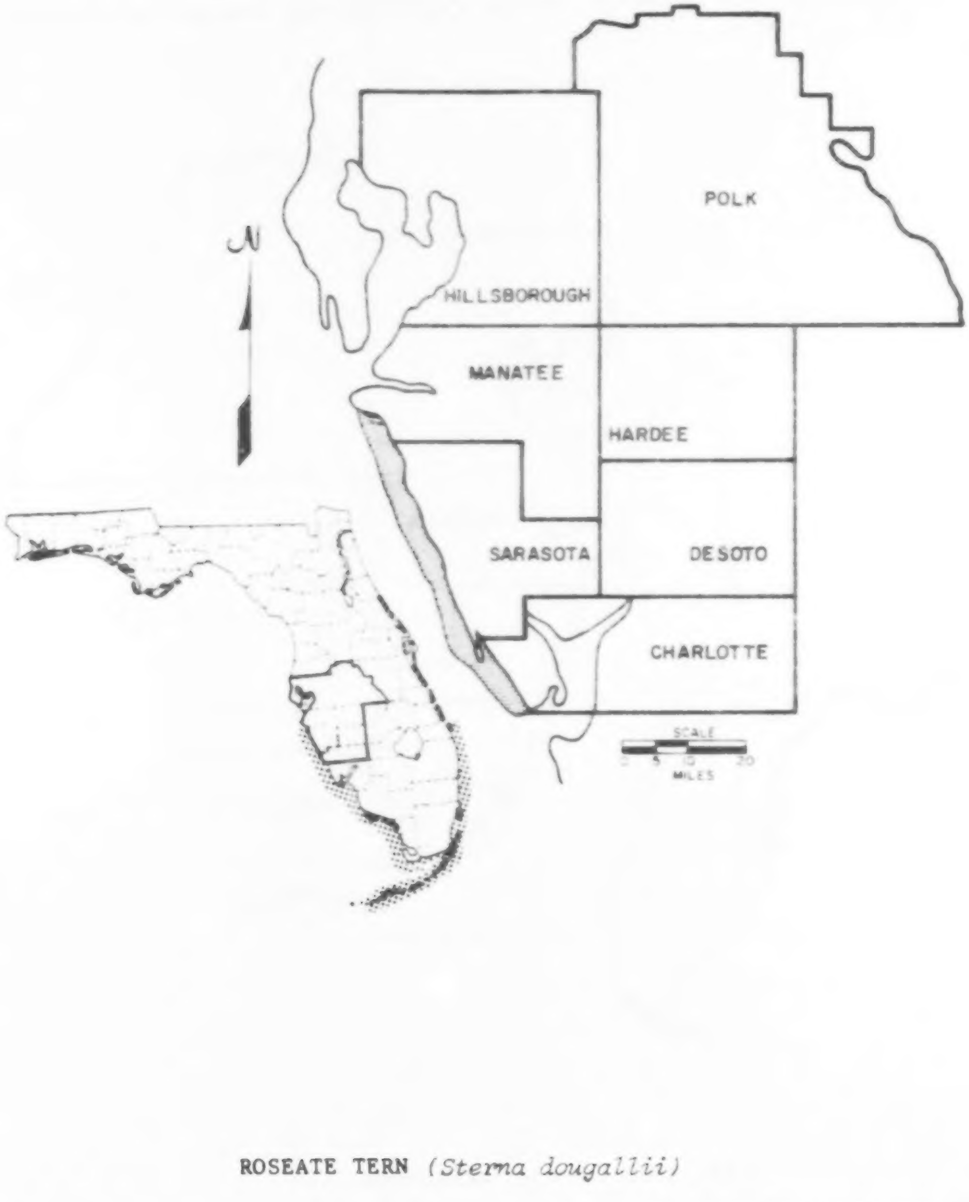
AMERICAN OYSTERCATCHER *(Haematopus palliatus)*

- Range: This species occurs in scattered colonies from Nova Scotia to Virginia and again along the Florida Keys and Caribbean islands, as well as from Europe to Africa in the eastern Atlantic.
- Habitat: The species is pelagic and rarely seen inland. It nests on a variety of beach substrates, from sand and gravel to bare stone.
- Status: This species was one of several which plume hunters almost exterminated during the 1800s. In Florida, nesting colonies are located only in the Keys. The birds are rare along the coastal part of the study area.



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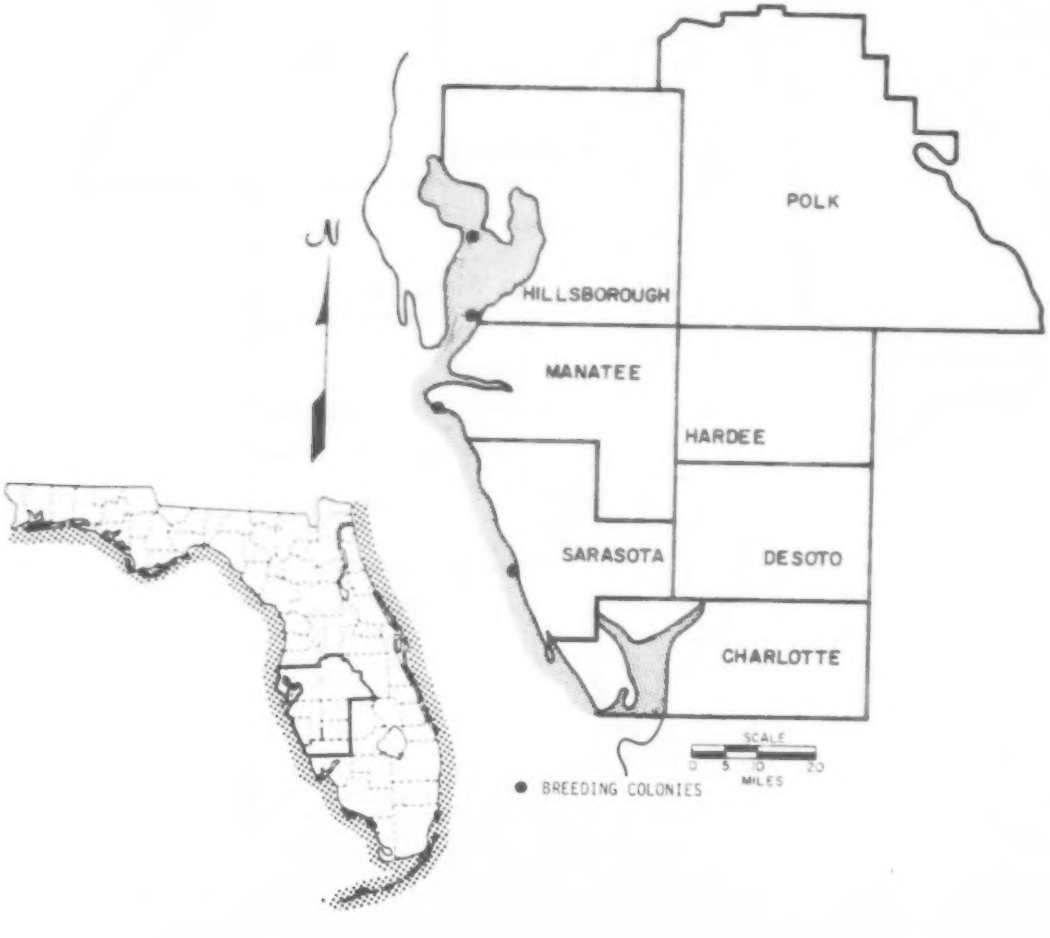
ROSEATE TERN *(Sterna dougallii)*

- **Range:** The Least Tern is distributed worldwide and breeds locally along the entire Florida coastline, with several colonies known to be in the 7-county study area.

- **Habitat:** Mud, sand, and gravel beaches of oceans, estuaries, lagoons, lakes, and larger streams are utilized during breeding periods; during other periods, all types of shallow, open, marine habitats are frequented.

- **Status:** During the late 1800s, plume hunters for the millinery industry all but extirpated the Least Tern, but the species made a substantial recovery because of the efforts of the Audubon Society. Presently, its greatest threat appears to be coastal development and associated activity.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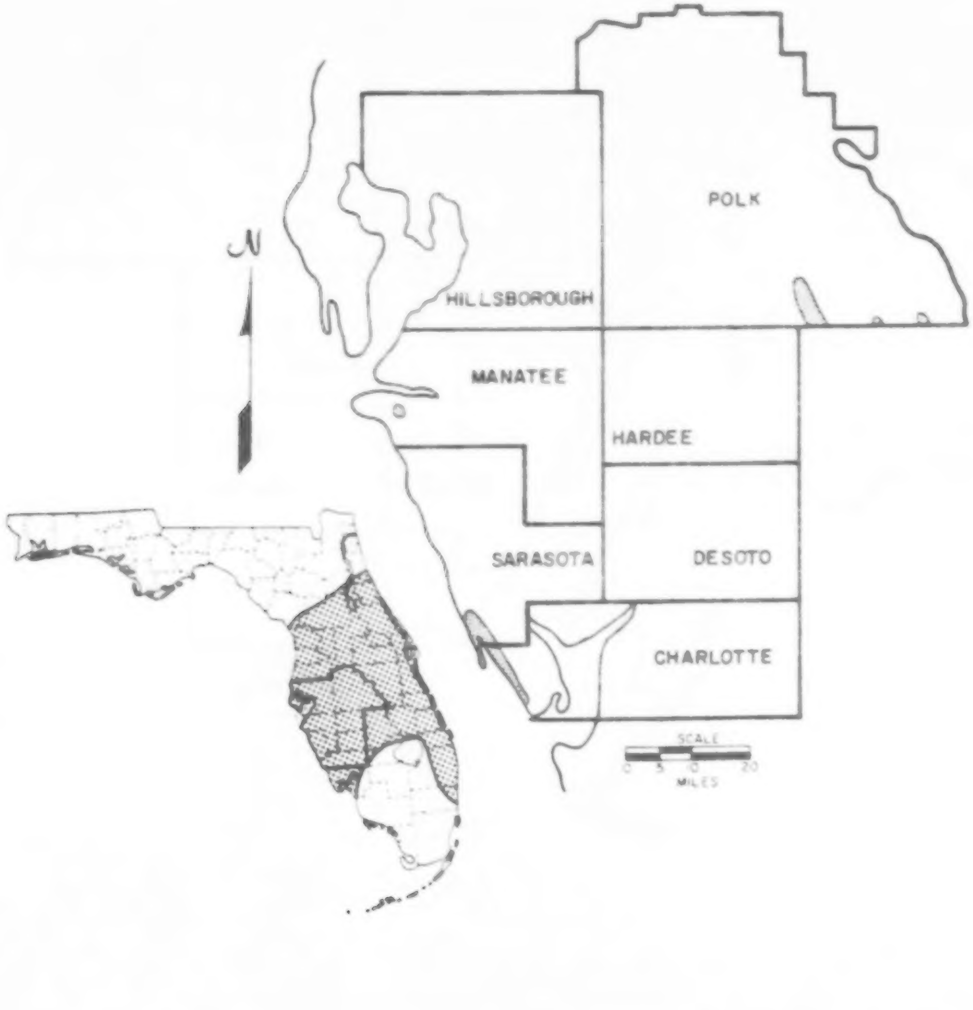
● BREEDING COLONIES

LEAST TERN *(Sterna albifrons)*

- **Range:** The Florida subspecies is found primarily in central Florida's sand pine scrub forests, and other subspecies occur in western states and Mexico.
- **Habitat:** In Florida, the Scrub Jay is restricted to the scrub oak habitat associated with well-drained sandy soils; rarely does it enter any of the several varieties of swamp forest available in Florida.
- **Status:** In recent years, rural development has drastically reduced the original Florida range of the Scrub Jay. The Scrub Jay has little habitat remaining in the 7-county study area and appears uncommon in areas where it does occur.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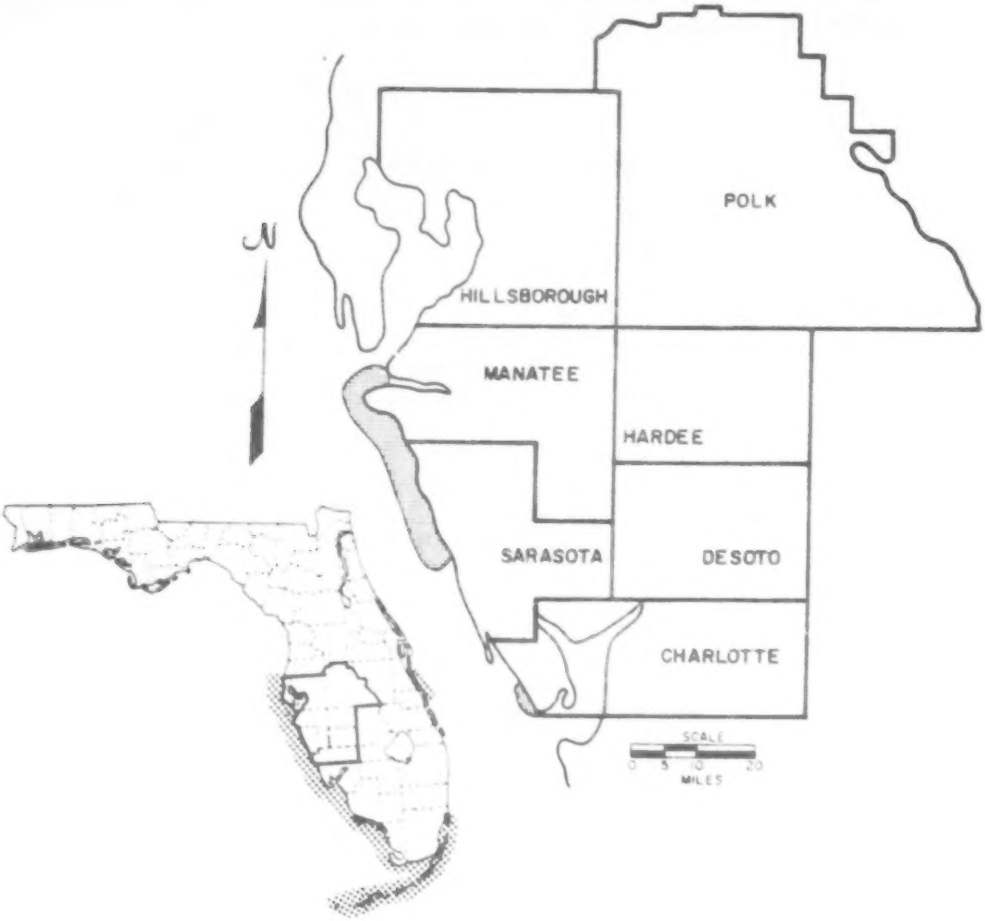
FLORIDA SCRUB JAY *(Aphelocoma coerulescens coerulescens)*

- **Range:** This species occurs along both coasts of Mexico and Central America, on various Caribbean islands, and in southern Florida.
- **Habitat:** As its name implies, it is primarily a bird of the mangrove swamp. Adjacent vegetation types are frequented, but it rarely lingers in other habitats.
- **Status:** The status of this species is at present questionable. Rather than declining, this bird appears to be extending its range. In the study area, it is rare.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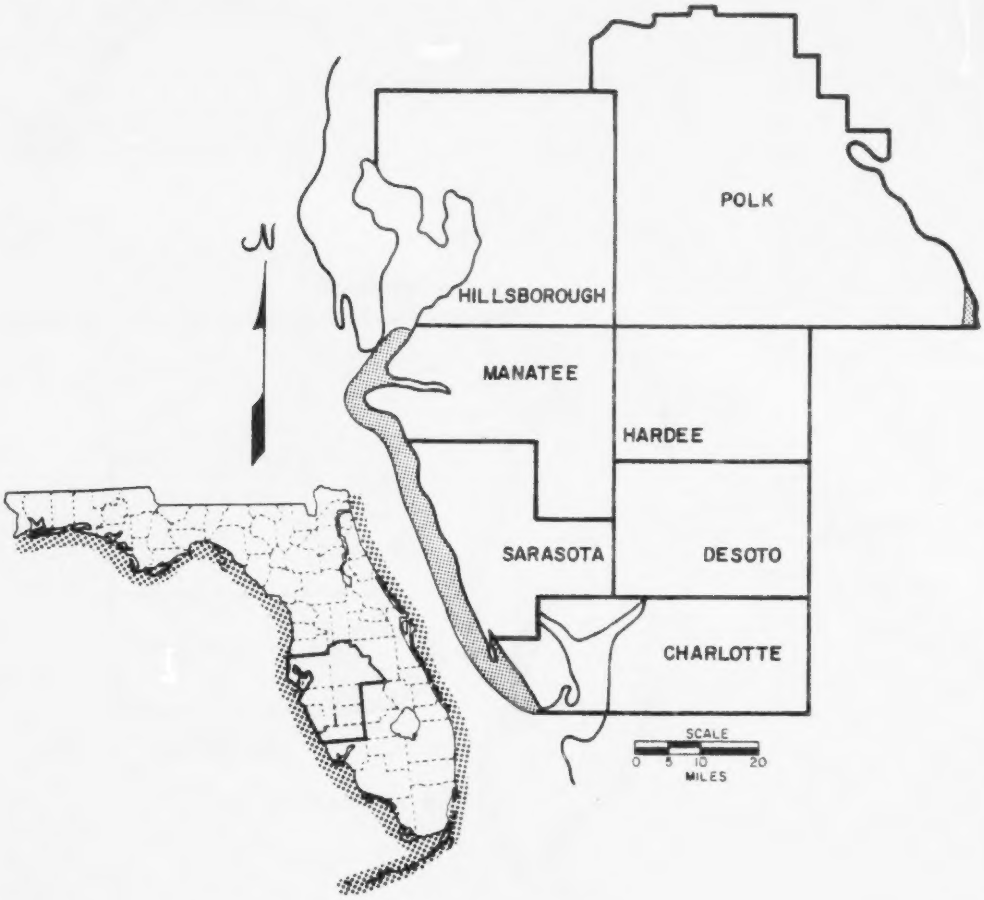
MANGROVE CUCKOO *(Coccyzus minor)*

- **Range:** The Great White Heron, a white morph of the Great Blue Heron, probably nests only in the Florida Keys and makes regular appearances along coastal areas and in some inland areas throughout Florida; inland records from other than southeastern Polk County are lacking in the 7-county study area.

- **Habitat:** Nesting sites are primarily on mangrove islands in estuarine or coastal areas. Feeding areas include a variety of offshore, as well as some inland, habitats.

- **Status:** Plume hunters reduced the original Florida stock during the late 1800s. As previously mentioned, all known breeding colonies are located at the southern tip of Florida. The white morph is uncommon in the study area.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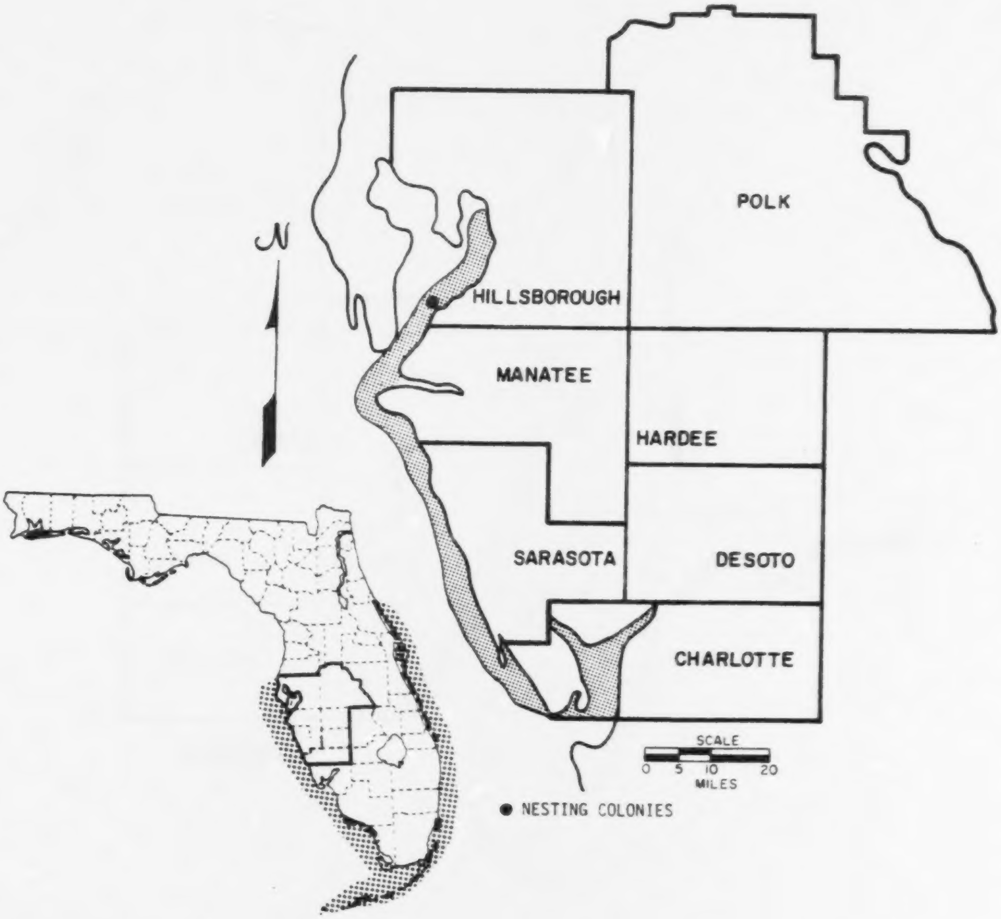
GREAT WHITE HERON *(Ardea herodias occidentalis)*

- **Range:** The Roseate Spoonbill occurs along coasts of peninsular Florida, Louisiana, Texas, and Mexico south to Argentina and Chile.

- **Habitat:** Spoonbills are predominantly coastal inhabitants, nesting in dense areas of red or black mangrove, generally on islands. Feeding grounds include such areas as coastal bays, brackish ponds, mangrove swamps and, occasionally, freshwater marshes.

- **Status:** In recent years, Spoonbills have appeared to be reestablishing in areas which they occupied before their decline during the late 19th century. However, they are generally considered rare and their nesting range is still extremely limited.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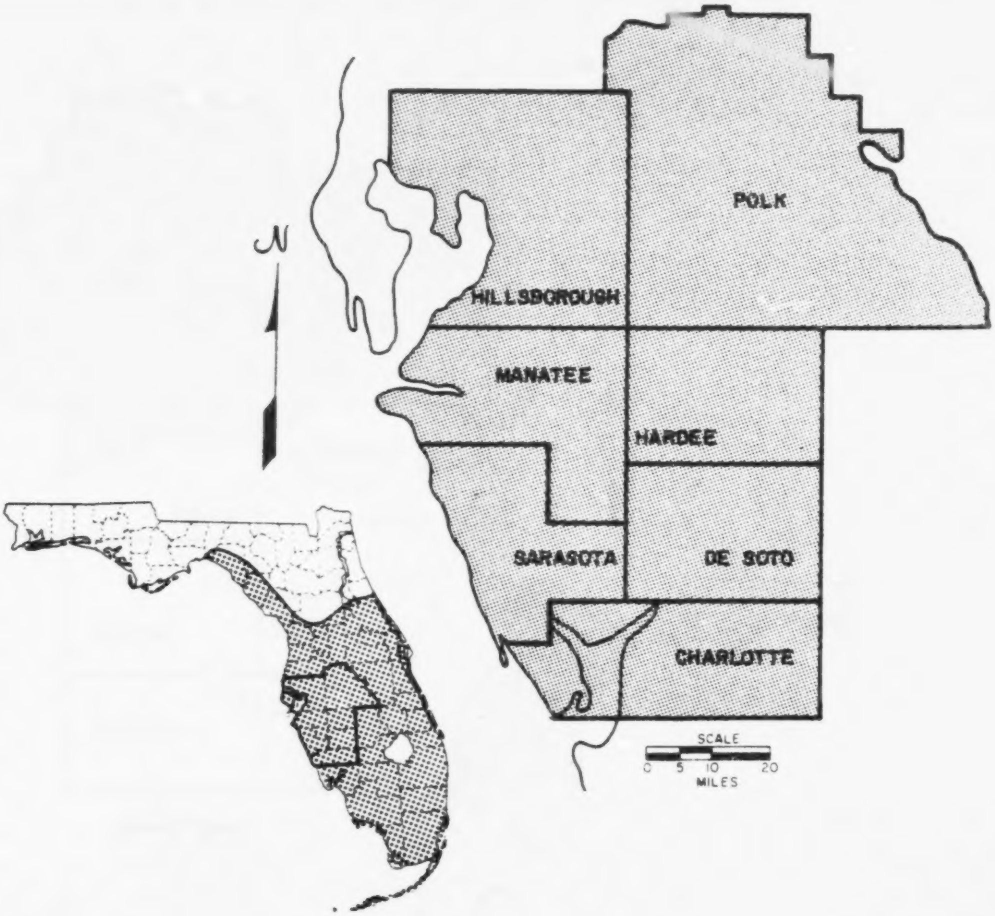
● NESTING COLONIES

ROSEATE SPOONBILL *(Ajaia ajaia)*

- Range: This hawk occurs in subtropical, tropical, and some temperate zones from Mexico south to northern Argentina, with a disjunct population in peninsular Florida. It does not commonly occur in any state other than Florida.
- Habitat: This species most commonly inhabits mature stands of cypress, riparian hardwoods, mangroves, and pines, appearing to prefer natural areas consisting of one of these woodlands in association with open marshland and prairie.
- Status: The disjunct Florida population presently consists of only a few hundred individuals, and in the study area short-tails are rare.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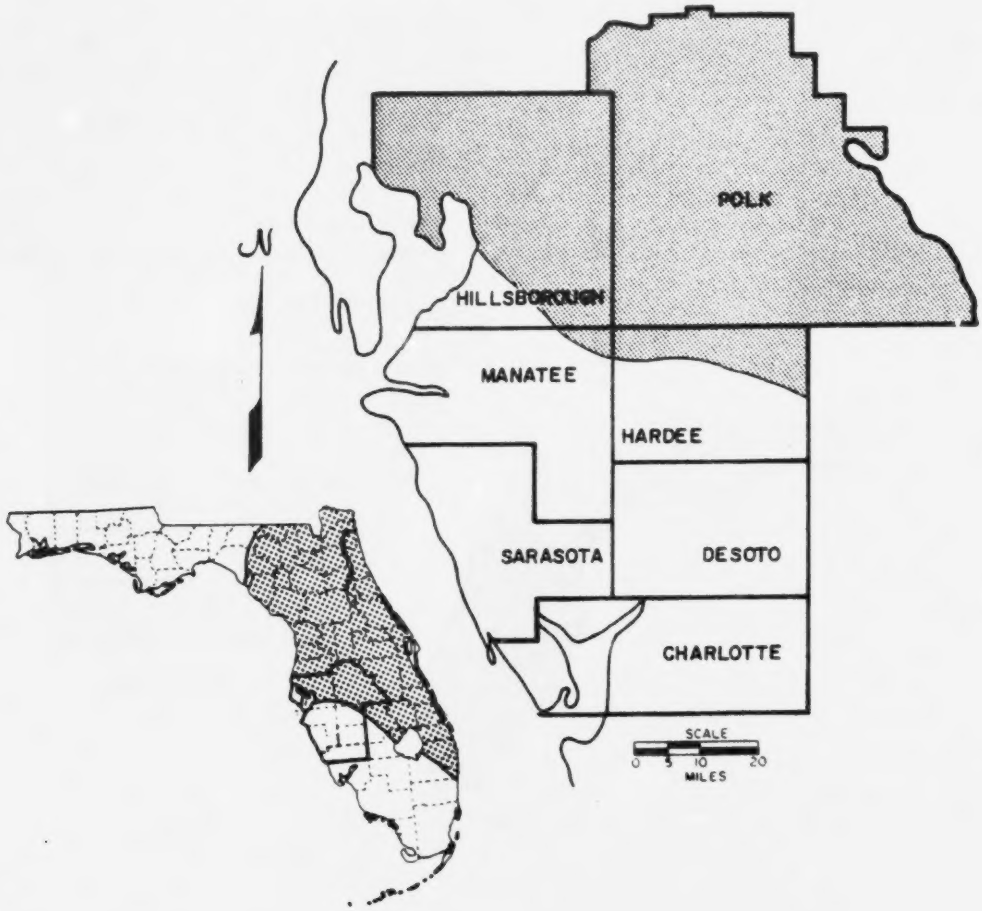
SHORT-TAILED HAWK *(Buteo brachyurus)*

- Range: This subspecies occurs locally south from Georgia throughout much of the Florida peninsula, including Hardee, Manatee, Polk, and Hillsborough counties within the study area.

- Habitat: The longleaf pine/turkey oak association of the sandhills is considered optimum habitat. Scattered small populations also occur in some ecotonal situations, including margins of flatwoods cypress ponds.

- Status: Within the study area, there are scattered small populations over much of Polk County and fewer patches in Hardee, Manatee, and Hillsborough. The survival of these remaining small populations is linked to conservation of the pine-oak forests. There is little doubt that numbers have reduced proportionally to habitat loss.



SHERMAN'S FOX SQUIRREL *(Sciurus niger shermani)*

- Range: This subspecies historically inhabited the deep southeastern United States but now probably does not exist outside Florida. The present range cannot be determined from available data but could include most of the state.

- Habitat: Forests are essential habitat for the panther. Generally, it is found in areas populated with white-tailed deer, the primary prey.

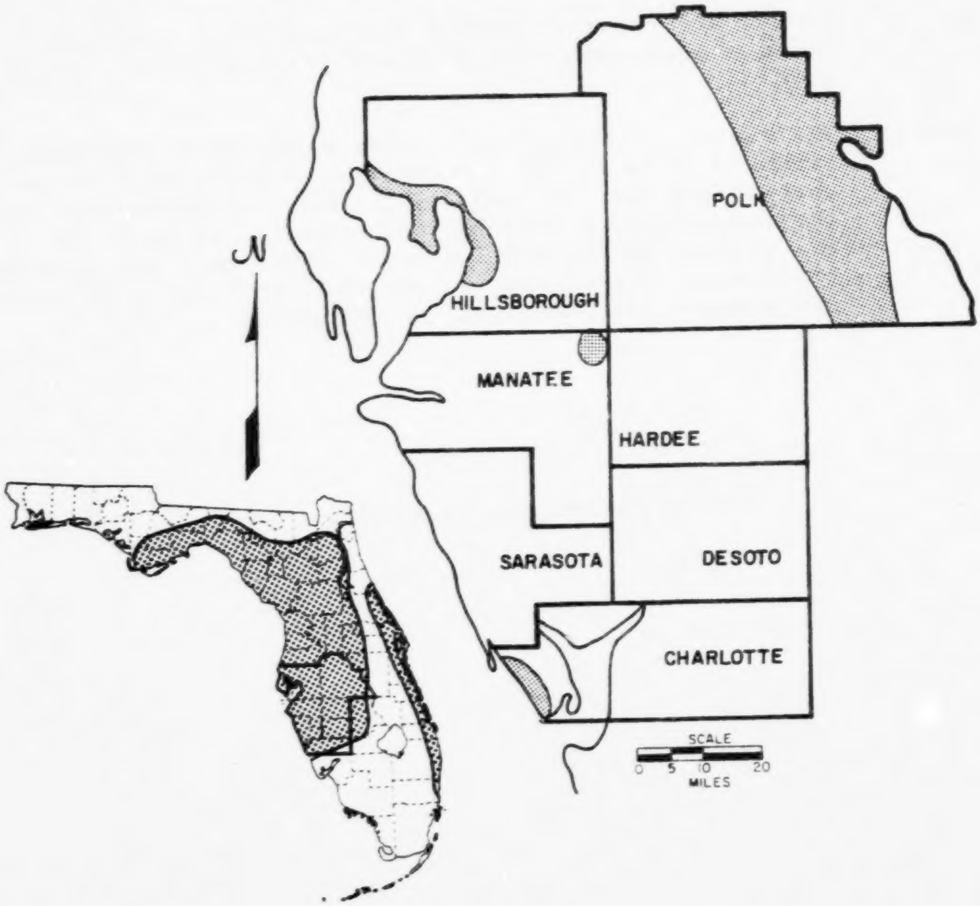
- Status: The number of remaining Florida panthers is uncertain but is estimated to be 25-300. Sightings or killings have been reported from over the state since 1971, but authorities question the authenticity of most of these reports, recognizing at most six records in the past 15 years. Shootings, more than habitat destruction or prey removal, are considered the prime factor in the probable extirpation of the subspecies.

FLORIDA PANTHER *(Felis concolor coryi)*

- Range: The Florida mouse is endemic to peninsular Florida; it occurs locally inland and along both coasts, except in the southern third of the peninsula where it is found only along the Atlantic Coast. In the study area, it is reported in Polk, Hillsborough, Charlotte, and Manatee counties.

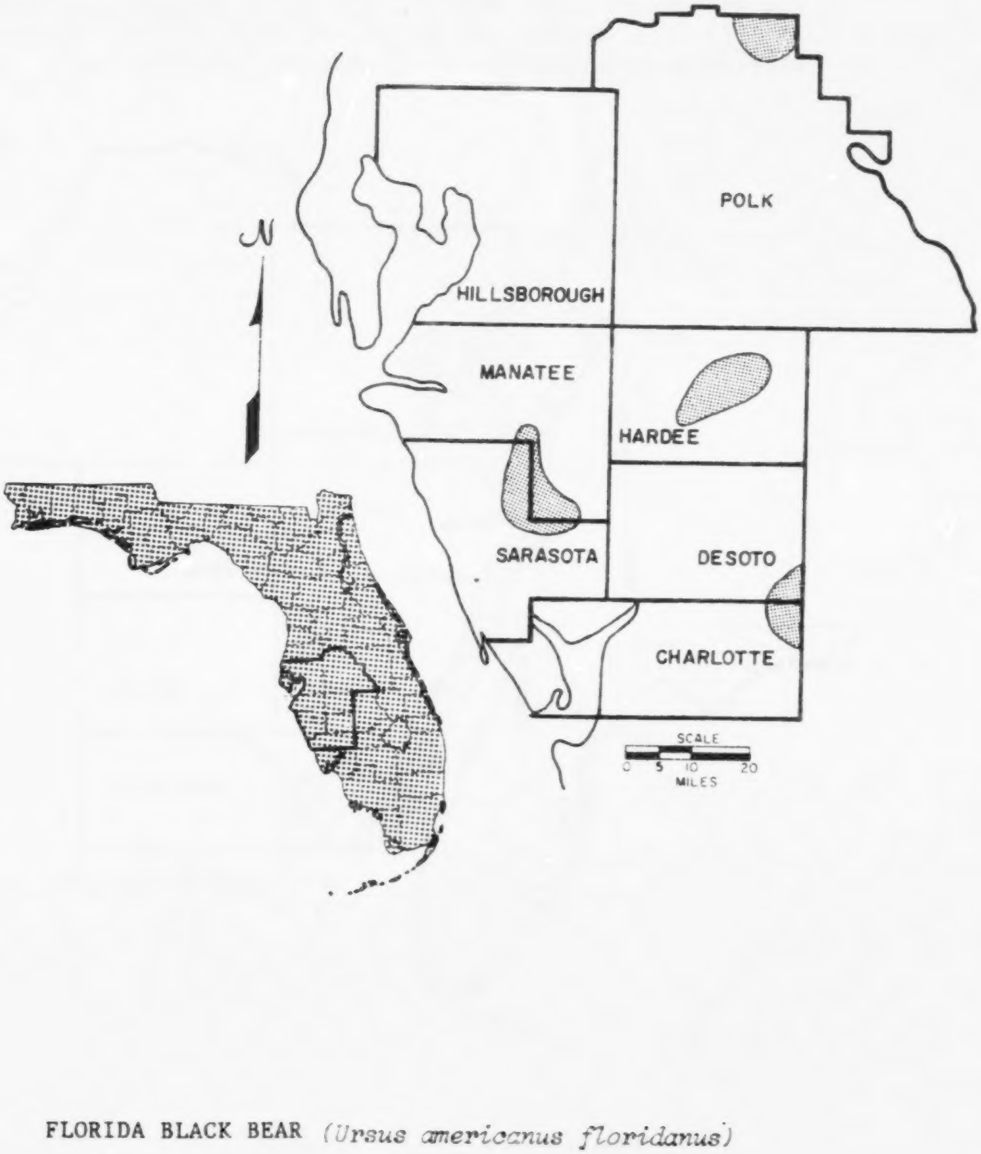
- Habitat: The Florida mouse reportedly has one of the narrowest habitat ranges of any Florida mammal, preferring early successional stages of sand pine scrub but commonly occurring in several other associations including turkey oak and pine flatwoods. Common characteristics of its habitats are shrubby vegetation combined with open bare areas and relatively well-drained sandy soils.

- Status: The well-drained sandy soil areas occupied by this species are in great demand by developers and citrus growers in Florida; the loss of sand pine scrub habitat, especially along coastal areas, is causing a decline in the overall population. The Florida mouse is rare in suitable habitat in the study area.



FLORIDA MOUSE *(Peromyscus floridanus)*

- Range: This subspecies exhibits patchy distribution over most of Florida and the southern peripheries of Georgia and Alabama. In the study area, it is found in all counties except Hillsborough.
- Habitat: Dense areas such as thickets and vine-choked bays that are considered generally impenetrable comprise bear habitat.
- Status: The bear in Florida is primarily concentrated in the Osceola and Apalachicola National Forests. In the study area, bear sightings are rare.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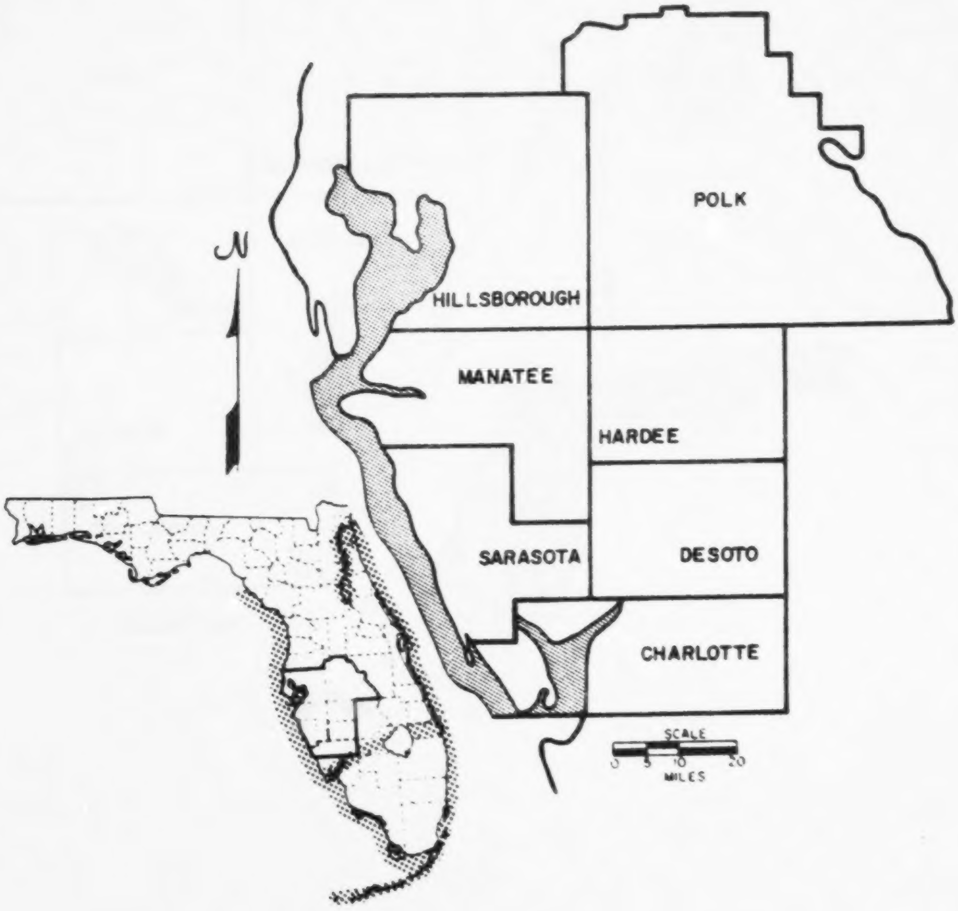
FLORIDA BLACK BEAR *(Ursus americanus floridanus)*

- **Range:** The manatee occurs along the coast of Georgia, both coasts of peninsular Florida, and the eastern coasts of Central and South America to northern Brazil.

- **Habitat:** Shallow estuaries, saline bays, and sluggish rivers are among the manatee's habitats. Habitats most used by the manatee within the study area appear to be the Myakka, Little Manatee, and Peace rivers.

- **Status:** Recent census records reveal that Florida has a manatee population of approximately 850 to 1000 individuals, less than half of which occur along the Gulf Coast. Although the manatee is protected by both the Endangered Species Act of 1973 (U.S. Public Law 93-205; 87 Stat. 884) and the Marine Mammal Protection Act of 1972 (U.S. Public Law 92-522; 86 Stat. 1027), vandalism and boating practices continue to threaten its survival.



MANATEE *(Trichechus manatus)*

In reviewing the status of the listed species, their habitat requirements, and their occurrences and abundances in the study area and state and the nature of potential environmental alterations accompanying further development of the central Florida phosphate mining industry, some species seem to be of greater concern that others — and within the category of "greater concern" are levels of concern based on, among other factors, the extent of Florida range outside the study area and whether the animal represents a species as a whole or is a subspecies. Of prime concern in this respect is the sand skink, one of three listed species endemic to Florida. The sand skink exhibits the narrowest range of the three endemic species: it is presumed to include a linear area from Marion County south to Highlands County that widens somewhat in southwestern Polk County. The other endemic species, the short-tailed snake and Florida mouse, exhibit somewhat wider ranges. The known range of the short-tailed snake includes most of Hillsborough and Polk counties and its southern extreme, with the greater part of the range being north of the study area up to Suwanee and Columbia counties. The range of the Florida mouse is similar to that of the short-tailed snake, with the exception of a disjunct strip along the Atlantic Coast. Within the western portion of its disjunct range, the Florida mouse occurs most frequently north of the study area. A locality record near the coast of Charlotte County and one in southern Highlands County extend the presumed range of the species through most of the study area. An important characteristic of the Florida mouse is that it is the only mammal species restricted to Florida. Both the sand skink and short-tailed snake also are important from a zoogeographic and biosystematic viewpoint: each comprises a monotypic genus and has no known close relatives anywhere in the world.

Listed subspecies that occur only in Florida are the blue-tailed mole skink, Florida Scrub Jay, and Florida Grasshopper Sparrow, all of which are races of species with relatively wide distribution, with that of the Grasshopper Sparrow being the widest. About half of the narrow range of the blue-tailed mole skink is in southern Polk County along the Lake Wales Ridge. A small portion of the limited breeding range of the Florida Grasshopper Sparrow also is in the southeastern part of Polk County. Local occurrences of the Florida Scrub Jay are less frequent in the study area than in other parts of its comparatively wide range in the state.

The Florida gopher frog, Florida Sandhill Crane, Florida black bear, and Sherman's fox squirrel are subspecies having ranges that include small areas in adjacent states but are largely within Florida. The Caracara and Short-tailed Hawk are widely distributed in Mexico and Central America (particularly the Caracara), with disjunct populations in Florida. In the U.S., the Caracara also occurs adjacent to Mexico but the Short-tailed Hawk occurs only in Florida.

These are among the principal species or subspecies of endangered or threatened status that will be addressed in the forthcoming environmental impact assessment. The Suwanee Cooter, American alligator, and manatee also will be addressed as species of greater concern (see Volume V, Chapter 2).

c. Ecologically Significant Species

Many species in the 7-county study area are not on special lists because of population decline but are nevertheless considered ecologically significant because their population dynamics are easily altered by outside influences. These species may be restricted to a specific habitat type or local geographic area, may be expanding their ranges, or may be considered an ecological indicator of environmental change. Recently introduced species that have become established also are included in this category. Ecologically significant species occurring in the study area are noted in Table 5.2.

d. Commercial and Recreational Species

Vertebrates considered commercially or recreationally valuable generally are game species or fur bearers. They are regulated by state laws that dictate harvesting seasons and limits in terms of hours and numbers, and methods. From an economic viewpoint, these species are considered desirable and worthy of conservation and management. Typically, they receive more public attention than all other categories combined: millions of dollars are expended annually by various governmental agencies for maintenance (including law enforcement) of these species and by the public for the right and means to harvest them.

Species commercially and recreationally important in the study area are indicated in Table 5.2.

e. Nuisance and Pest Species

One commonly thinks of a nuisance or pest species as being either aesthetically, economically, or medically undesirable. Local abundance is a major factor in designating a pest species. For example, one or several Red-winged Blackbirds feeding in a grain field are unimportant but large flocks may cause economic damage.

Contacts with some of the county health departments and county agents in the study area indicated that vertebrate pest species have caused little trouble in the study area in recent years. Certain reptiles (e.g., alligator, diamond-back rattlesnake) are potential health hazards in the event of local population buildup. Among the birds and mammals, the Starling, House Sparrow, black rat, house mouse, and Norway rat are universal pests in situations that present unlimited optimum habitat; and the Rock Dove and armadillo, both common in the study area, are potential nuisances in some instances. Of these, the Norway rat, because of its aggressiveness and disease-carrying potential, is probably the most offensive. According to health department information, the study area experiences isolated abundances but these incidences are not considered hazardous.

Certain vertebrates (e.g., skunks, gray fox, bats) transmit rabies to domestic animals, which then may transfer the disease to humans. Rabid raccoons as well as a fox and bat have been found in the study area (Sarasota County) in the past few months, but no cases of human rabies have been reported (Sarasota County Health Department 1977). Human rabies has not occurred over the entire state during the past 2 years, nor have there been any recent cases of avian-borne diseases (e.g., psittacosis, some forms of encephalitis).

2. Invertebrates

a. Threatened or Endangered Species

The 1974 U.S. Department of Interior list of threatened or endangered species contains no invertebrates. Since the compilation of the 1974 list, however, several invertebrates have been determined to be either threatened or endangered or have been proposed as such. While none of these species have been found in the 7-county study area, some (e.g., Schaus swallowtail and

Bahama swallowtail butterflies; Stock Island tree snail) do occur in other Florida localities (Federal Register 1976a, 1976b).

FCREPA's 1976 list (Florida Committee on Rare and Endangered Plants and Animals 1976) indicates nearly 100 species of insects and other terrestrial invertebrates to be endangered, threatened, of special concern, or of undetermined status. Distributions of somewhat more than half of the species were obtained from the literature or members of FCREPA's special committee on insects and terrestrial invertebrates. Six of these species are recorded from one or more counties within the study area (Table 5.4). Two species were indicated by the responding authority as probably occurring in the study area, and four species recorded from adjacent counties may occur in the study area in similar habitat.

Table 5.4. FCREPA-Listed Insects and Other Terrestrial Invertebrates Reported from or Near Study Area

Common Name	Scientific Name	Status	County*	Habitat*
Gopher tortoise copris beetle	*Copris gopheri*	Threatened	Highlands, Pinellas	Burrows of gopher tortoise
Southwest Florida wingless burrowing beetle	*Mycotrupes pedester*	Threatened	Charlotte, DeSoto	Sandpine scrub
Peninsular gopher tortoise dung beetle	*Onthophagus polyphemi polyphemi*	Threatened	Hillsborough	Burrows of gopher tortoise
Gopher tortoise aphodius beetle	*Aphodius troglodytes*	Threatened	Highlands	Burrows of gopher tortoise
Abbot's purse-web spider	*Atypus abotti*	Special concern	Probably in study area	Mesic situations
Florida trap-door spider	*Ummidia* sp.	Special concern	Probably in study area	Mesic situations
Scarab beetle	*Copris howdeni*	Undetermined	Manatee, Polk	Unknown
Scarab beetle	*Peltotrupes profundus*	Undetermined	Hillsborough	Deep sand in scrub or sandhill
Scarab beetle	*Aphodius aegrotus*	Undetermined	Hillsborough	Burrows of southeastern pocket gopher
Scarab beetle	*Onthophagus aciculatulus*	Undetermined	Pinellas, Pasco	Unknown
Horse fly	*Asaphomyia floridensis*	Undetermined	Highlands	Xerophytic scrub
Horse fly	*Tabanus cayensis*	Undetermined	Manatee, Charlotte, Hillsborough, DeSoto Sarasota	Salt marsh

*Woodruff 1973; Berner, Fairchild, Wallace, Westfall, personal communications.

b. Ecologically Significant Species

Invertebrate species that are restricted to specific habitats, occur in local populations, or are indicators of environmental change are numerous. Many such species, particularly among the arthropods, have been recorded from the study area; many others undoubtedly are present although not recorded; and others remain unrecognized as ecologically significant because either the species, their biologies, or their distributions are unknown.

Perhaps the best known of the ecologically significant invertebrates are those sensitive species that are indicators of environmental quality. Because of early emphasis on water quality, most of the known "indicator" species are aquatic; some terrestrial species, however, particularly soil arthropods (Cornaby 1974), are receiving attention.

c. Commercial and Recreational Species

Among the commercially and recreationally important terrestrial invertebrates are various species of earthworms and insects that are used for fish bait. Most of the species that are sold in bait shops or roadside stands are cultured, generally in a contained, controlled environment; comparatively few individuals (usually for personal use) are harvested from wild populations.

The most directly valuable terrestrial invertebrate in the study area is the honey bee (*Apis mellifera*), which is cultured in the sense of controlled colonization but must feed on local vegetation. Most of the food for bees in Florida, as elsewhere, comes from wild plants; a smaller portion comes from cultivated ornamentals, crops, and citrus (Morton 1965). Of the various kinds of honey produced (depending on pollen or nectar source), orange honey is the major commercial quality crop in both the study area and Florida as a whole (Morse 1956): not only do local beekeepers benefit from the large production of orange honey but also those from other states (adjacent states primarily), who have moved as many as 20,000 colonies in and out of the citrus belt each year (Morse 1956). Historically, Florida has ranked around third nationally in annual honey production (Morse 1956) and recently vied with California for first or second ranking, with weather conditions generally determining total yield (Rozar 1977). Since flower production in a given plant species usually is seasonal, several species, or nectar sources, must be available to maintain such a large honey crop. Wax myrtle, a common plant in hammocks, pine flatwoods, and swamps, is an important source of nectar in the study area during winter and spring (Morton 1965). Among other important plants in the study area are willow (December-February), saw palmetto (April-June), buttonbush (late May-September), and gallberry (March-May). Nectar from these plants is abundant but, most importantly, the honey is of commercial quality. Melaleuca produces copious nectar that makes poor quality honey but is useful for hive maintenance and therefore important to the beekeeper. In the coastal part of the study area, black mangrove produces copious nectar from April through August, but again the quality of the honey limits its usefulness to hive maintenance. Seagrape in that area, however, produces copious nectar that makes good quality honey.

Enhancing the commercial value of the honey bee is its role in crop pollination. Honey bees accomplish 90-95 percent of pollination among watermelon, cucumber, squash, and cantaloupe, all of which are wholly dependent on insect pollination (Morse 1956). Strawberry production, which is important in the study area, is partially dependent on insect pollination, primarily honey bee.

d. Nuisance or Pest Species

Also quite numerous among terrestrial invertebrates are the nuisance or pest species, and they generally are better known than the less troublesome species. As in the case of vertebrate pests, invertebrates generally reach pest proportions only in situations that provide unlimited optimum habitat, often supplied by human activity. Prominent among nuisance terrestrial invertebrates in the study area are the lovebug (*Plecia nearctica*) and midges.

The lovebug, a March fly, emerges year-round in Florida, with emergence peaking in May and September (Hetrick 1970). Extensive flights during those months have persisted since 1966 in northcentral Florida and since 1969 in more southern portions of the state. The flies breed most successfully in oak hammocks and other habitats that retain moisture (Hetrick 1970). Extensive larval development has been noted under weathered cow manure in low pasture areas. The larvae feed on decaying vegetation. The primary nuisance factors associated with swarms are impairment of driver vision and damage to automobile cooling systems. Because of impingement on freshly painted exterior surfaces, house painting often is suspended during May and September. There are no effective control measures for the fly, although, according to county agents in the study area, intensive research on the problem has begun.

Midges, which with few exceptions are aquatic in the larval stage, also comprise extensive swarms as adults, interfering with human activities, particularly in recreational areas; most adults are intensely attracted to lights, so swarms occur around porch lights and camp lights. Midges normally are abundant in most freshwater habitats, and even greater populations of certain species can exist in water bodies where nutrient richness is naturally or artificially high. In Florida, as elsewhere, the production of midges in nuisance proportions is partly attributed to water management techniques and effluents associated with growth and development of human population centers and industrial activity (Beck and Beck 1959). A research laboratory sponsored by the state has been established at Winter Haven to study the midge problem. At least six of Florida's more than 100 midge species may create nuisance conditions (Beck and Beck 1959), and all six species occur in both the Central Highlands and Coastal Lowlands regions of the state. In the study area, extensive midge-related nuisance conditions apparently are not common; according to insect control agencies there, midge hatches are occasionally reported but the incidences generally are isolated and short-lived. According to the Hillsborough County Mosquito Control, a recent intense local incidence in the county was related to fertilizing artificial lakes in the area.

Pest species of economic concern in the study area are those associated with citrus and truck crops. The spotted cucumber beetle (*Diabrotica undecimpunctata*), cabbage looper (*Trichoplusia ni*), fall armyworm (*Spodoptera frugiperda*), corn earworm (*Heliothis zea*), and pickleworm (*Diaphania nitidalis*) are prominent pests on cucumber and watermelon. Locally, the cabbage looper, fall armyworm, and corn earworm are referred to as a single entity, the watermelon rindworm (Mead 1976). These species, all widely distributed in the United States, were considered important enough in croplands of the study area in 1976 to be chemically controlled (Texas Instruments 1977). Prominent pests on tomatoes and peppers, along with the corn earworm, are the tobacco and tomato hornworms (*Manduca sexta* and *Manduca quinquemaculata*); both are widespread in the

United States, but the tobacco hornworm is more abundant in Florida (Kimball 1965). The primary pest on strawberries, the other major truck crop in the study area, is the Pamera bug, a complex of seedbugs in the genus *Pamera*; these insects apparently are greater pests in home gardens, causing little economic damage to strawberry crops (Rozar 1977). Citrus pests are numerous: 12 species of mites are known to feed on the wood, leaves, and fruit of citrus trees and to interfere with the health of the plant or blemish the fruit (Muma 1975). A whitefly, the citrus blackfly (*Aleurocanthus woglumi*), currently perhaps the most serious citrus pest in Florida, injures the plant by sucking fluids from the leaves; a sooty fungus that grows on honeydew deposited by the feeding insect often interferes with phytosynthesis. This pest is spreading northward from southern Florida but has not reached the study area.

Of the several insects that transmit diseases, the mosquito is most prevalent. In the study area, certain forms of encephalitis are the only human diseases of concern carried by mosquitoes. Of the 40-50 species of mosquitoes in the study area, three are potential carriers of the disease. According to county health departments in the area, contacts among reservoirs of the disease (primarily birds), mosquitoes, and humans are rare. No encephalitis has been reported in the state during the past 2 years, and there has been no incidence of concern in several years.

D. WETLANDS

Forested and nonforested wetlands (Level II, Anderson et al 1976) in the study area as of 1973 are delineated in Plate 4 (in map pocket). In Table 5.1 are the areal extents of the wetlands and surface water in the study area and each county, as well as the areal extents of Level I vegetation types. Also appearing earlier in this document in the discussion of habitat types are vegetative descriptions of wetlands in the study area. Additional discussion of wetlands characteristics appears in Chapter 2 of Volume V.

Man has long recognized the value of wetlands. Among their attributes, wetlands serve as wildlife and fish habitat, natural fire breaks, and outdoor laboratories; store ground water; retain surface water and stabilize runoff; play a role in land stabilization and domestic waste treatment; reduce/prevent erosion; produce timber and cash crops; and provide fishing and hunting (Shaw and Fredine 1956). The following topics were considered in discussing the ecology of wetlands in the study area:

- Relative productivity
- Important invertebrates
- Nursery ground activity
- Waterfowl usage
- Threatened and endangered species

1. Stabilizing Effects

As interfaces between uplands and water bodies, wetlands are important buffer zones that prevent erosion and stabilize water flows (Wass and Wright 1969); the vegetation acts as a constraint against tidal currents and flood waters and collects sediment.

Wetlands retain surface water for longer periods of time than do uplands. Suspended sediments either precipitate downward or are washed downward by rain to the wetlands surface, where they build up or are flushed into creeks by rain or tides. Upstream swamps catch much of the coarse material before it reaches marshes; marshes, especially coastal marshes, generally catch finer particles. The rate at which sediment accrues in wetlands, particularly marshes, depends on several factors including type of vegetation and the extent of the wetlands compared with that of the watershed. In any case, a significant amount of sediment is caught, reducing the sediment load of a stream entering an estuary and lessening siltation at that point. Within coastal marshes, erosion of the marsh's creek banks may occur from animal usage; however, fibrous roots of *Spartina* often hold the fine cohesive sediments, and a dynamic equilibrium prevents lateral expansion by creek currents or encroachment of vegetation. Without the resistant material confining the marsh channels, erosion would rapidly alter them.

Wetlands act to slow runoff after rains. They retain surface water partly by absorbtion. Both peat and silt-clay particles, if not too compact, are good absorbers. The water is released slowly, some of it as groundwater recharge. If drawdowns of the groundwater table occur, a deep peat or muck marshland possibly contributes most of the rain falling on it to groundwater rather than to the estuary.

In Florida, mangrove swamps as well as other wetlands are important in stabilizing the coastal areas. Accretion of sediment along coasts is regulated by several processes including the rate at which sediment is brought into an area by rivers and tides, the angle of slope of the shore, sedimentary distributional patterns, subsidence or emergence of the coast, and tidal-river channel development (Walsh 1974). A long-held view that new land is formed by mangroves trapping sediments and other marine debris has been questioned. In an early work, Davis (1940) stated that mangrove swamps and salt marshes extended coasts and islands; a later viewpoint discussed by Carlton (1974b) is that mangroves merely modify the rate at which geomorphic processes take place, thus affecting the speed of the process rather than its direction. This latter viewpoint is becoming widely accepted, and interest recently has centered on using transplanted mangroves as natural stabilizing agents along Florida shorelines.

2. Relative Productivity

Basic productivity (organic matter produced by photosynthesis) of saltmarsh plants is relatively high compared with that of upland and crop plants (Humm 1973). In comparing various ecosystems in terms of gross primary productivity by dry weight of organic matter fixed annually, Odum (1961) estimated production of grasslands, forests, and ordinary agriculture in thousands of pounds per acre per year and estuaries and deltas in ten thousands. Saltmarsh annual production has been measured at many locations along the South Atlantic and Gulf coasts; production usually ranges between 8,000 and 20,000 pounds per acre (9000-22,500 kilograms per hectare) (Turner 1976).

Most of the organic matter of a salt marsh is decomposed within the marsh, but some is carried to sea and decomposed there. Therefore, released inorganic nutrients are either recycled in the marsh through a variety of food chains or in the sea (Humm 1973). The proportion (often large) of the annual production exported to deeper waters supports detritus-based food chains comprising animals of importance to man. In monetary terms based on the gross primary productivity, an ecological life-support value of approximately $4,000 per acre per year is realized (Gosselink et al 1974). When the annual value is income-capitalized, the estimated total values are $50,000-$80,000 per acre (Gosselink et al 1974).

The per-acre productivity of freshwater wetlands, which has received comparatively little attention, generally is less than per-acre productivity of brackish or saltwater wetlands. Productivity of areas in Big Cypress Swamp averages around 10,000 pounds per acre (9,900 to 11,700 kilograms per hectare) (Carter et al 1973). Plant diversity is greater in freshwater wetlands, however, providing a variety of food and habitat for the diverse associated fauna. Vertebrate species rare in the study area that are exclusively supported by wooded wetlands are otters, which feed on abundant crayfish; round-tailed muskrats, which feed on abundant aquatic vegetation; and the Limpkin, which feeds on the abundant snail crop (Wharton 1976).

Freshwater wetlands have been shown to act not only as sponges holding water back but as filters cleaning waterways of wastes, some of which increase productivity (Wharton 1976). A cypress pond can accept partially treated urban wastes, act as a secondary or tertiary treatment plant, and grow trees faster. Spray irrigation of wastewater effluent is an effective method of waste treatment and water recharge involving a natural system, but in Florida particularly, a wetlands system can reduce the cost of transport and distribution of the wastewater (Boyt et al 1977). Fertilizers, pesticides, heavy metals, and even radioactive wastes have been processed by river swamps, either by binding them to sediments and depositing them out on the floodplains to be broken down or immobilized or by locking them into harmless form by organic molecules and carrying them downstream to the estuary (Wharton 1976).

Vital to the effectiveness and productivity of Florida wetlands is alternating inundation and water release: to maintain desirable production levels in wetlands. maintenance of the water table and periodic flushing is important; otherwise, as in the case of ponds, which are not flushed, materials accumulate and slowly fill in the depression.

3. Important Invertebrates

Coastal wetlands within an area support various species and abundances of invertebrates, depending on salinity conditions, among other factors. Brackish marshes generally support fewer species than do salt marshes, and within a salt marsh, abundance of a species may vary on seasides and baysides (Wass and Wright 1969). Within the study area, distribution may vary somewhat between salt marshes dominated by smooth cordgrass and areas dominated by mangrove; most species are distributed in both wetlands, but not necessarily in the same abundances. It should be noted that the study area's tidal-marsh acreage is small compared with that of mangrove swamp (see Chapter 2 of Volume V).

Important invertebrate groups within coastal wetlands include polychaetes, bivalves, snails, and crustaceans as well as insects. Taxa commonly associated with coastal marsh/mangrove communities in the study area (Humm 1973, Florida Department of Natural Resources 1975) include:

- Polychaete worms

Neanthes succinea
Arenicola cristata
Capitella
Branchioma nigromarginata

- Crustaceans

Ivory barnacle	*Balanus eburneus*
Shrimp	*Palaemonetes intermedins*
Sand shrimp	*Crangon*
Crab	*Panopeus*
Fiddler crab	*Uca rapax*
Fiddler crab	*Uca pulilator*
Mangrove crab	*Aratus pisonii*
Crab	*Sesarma curacaoense*
Stone crab	*Menipe mercenaria*
Wood-boring isopod	*Shaeroma destructor*

- Snails

Eastern nassa	*Nassarius vibex*
Coffee-bean snail (saltmarsh pulmonate)	*Melampus coffeus*
Marsh periwinkle	*Littorina irrorata*
Augulate periwinkle	*Littorina angulifera*
Virgin nerite	*Neritina virginea*
Olive nerite	*Neritina reclivata*
Ladderhorn snail	*Cerithidea scalariformis*

- Bivalves

Clam	*Mya*
Hard clam	*Mercenaria*
Marsh clam	*Rangia cuneata*
Clam	*Macoma mitchelli*
Scorched mussel	*Brachidontes exustus*
Ribbed mussel	*Geukensia demissa*
Conrad's false mussel	*Conceria leucophaeta*
Eastern oyster	*Crassostrea virginica*
Coon oyster	*Ostrea frons*

- Insects

Saltmarsh greenhead horse fly	*Tabanus nigrovittatus*
Mosquitoes	*Culicidae*

Other groups of invertebrates, particularly nematodes, undoubtedly are important in coastal wetlands but generally are excluded from studies, so information on them is sparse (Humm 1973). A number of invertebrates, particularly insects and spiders, are important as plant feeders or predators associated with the emergent vegetation in the coastal wetlands.

In freshwater marshes and swamps, insects are most important among the aquatic macroinvertebrates, with water mites, tubificid oligochaetes, and crayfish also important. Of these, midges among the insects and tubificid worms seem prevalent in marshes and swamps of the study area. Most comprehensive distribution data on freshwater invertebrates in the study area applies to lake or stream species. The following list of common taxa in a marsh/cypress swamp interface is from a single study conducted on a site in DeSoto County (Texas Instruments 1977):

- Insects

Midges	*Tanytarsus*
Dragonfly	*Pachydiplax longipennis*
Damselfly	*Ischnura ramburi*
Predaceous diving beetle	*Thermonectus basillaris*
Predaceous diving beetle	*Cybister fimbriolatus*
Water scorpion	*Ranatra buenoi*
Waterboatman	*Sigara*

- Other invertebrates

Water mites	Prostigmata
Oligochaete worms	Tubificidae
Crayfish	Astacidae

Since many freshwater wetlands species occur in a variety of standing aquatic habitat including ponds, borrow pits, sink holes, and pools formed by irrigation runoff, several species listed as occurring in standing freshwater communities in the study area (see Chapter 2 of Volume V) undoubtedly may be found in the wetlands. Filter feeders similar to those predominating in coastal wetlands or running freshwater are absent since there are no currents and tides to bring food. Motile detritus feeders and their predators comprise most of the freshwater wetland species. Each taxon listed as common in the coastal or freshwater wetlands is considered important in food webs within the systems. Those wetlands species of social or economic importance are discussed either in other sections of this volume or in Chapter 2 of Volume V.

4. Nursery Ground Activity

Nutrients flushed from wetlands by tides or rainfall support a complex food web in adjacent waters. Part of the food web comprises certain juvenile fishes and shellfishes that use the bordering waters of wetlands as nursery grounds. Juveniles using the wetlands as nursery grounds either migrate into the nursery as larvae, are spawned there by migrating adults, or are carried there by tides. Not only is food plentiful, but predation apparently is less of a threat in the generally turbid nursery ground waters than in open waters (Wass and Wright 1969).

Another factor contributing to the success of nursery grounds is timing of migrations of various species so that little overlap occurs in their occupation of the areas. Also, trophic levels and/or space often separate species occupying the areas at the same time. Although migratory juveniles must compete with juvenile and adult resident fishes as well as migrating adults of the same species, often they occupy different areas in the nursery ground (e.g., juveniles may migrate farther upstream than adults) or they consume different foods. Nursery function and species associated with tidal wetlands in the study area are discussed in Chapter 2 of Volume V.

5. Waterfowl Usage

Waterfowl populations are largest in Florida from December through late January (Chamberlain 1960). During a recent January, approximately one-fifth of the Atlantic flyway population of 2,000,000 waterfowl was in Florida (Benning et al 1975). Despite the wide distribution of lakes, ponds, streams, marshes, and other waterfowl habitat, the bulk of wintering waterfowl normally is on only about 4 percent of the total state area (Chamberlain 1960). Traditionally, waterfowl use little of central Florida. In the study area, waterfowl habitat comprises 178,000 hectares (440,000 acres) of wetland and approximately 67,000 hectares (166,000 acres) of water, which includes canals, streams, lakes, reservoirs, bays, and estuaries (Table 5.1). Offshore waters beyond the limits of bays and estuaries provide additional waterfowl habitat.

Waterfowl species recorded from the study area include 1 swan, 3 geese, 31 ducks, and the American Coot (*Fulica americana*). The Coot is a duck-like species related to gallinules and rails and is normally included in waterfowl surveys; it migrates to Florida in large numbers, comprising 30-40 percent of Florida's winter waterfowl population (Benning et al 1975, Chamberlain 1960). The most abundant duck species wintering in Florida is the Lesser Scaup (*Aythya affinis*); it comprises approximately 30 percent of Florida's waterfowl population in midwinter (Chamberlain 1960) and generally is found along the coast, being particularly abundant in the bays and estuaries of Hillsborough and Charlotte counties. Most of the other diving-duck species except the Ring-necked Duck (*Aythya collaris*) also prefer brackish and salt water along the coast. The most abundant dabbling duck wintering in Florida (Chamberlain 1960) is the Pintail (*Anas acuta*). The only ducks that breed in Florida are two other dabbling duck species: the Mottled Duck (*A. fulvigula*), often called the Florida Duck; and the Wood Duck (*Aix sponsa*). Charlotte County is in the heart of the Mottled Duck range (Chamberlain 1960). Mottled Ducks nest in irrigated active croplands, wet prairies, and shallow freshwater marshes, whereas Wood Ducks are found in wooded swamps and hammocks, where they nest in tree cavities.

Open water and wetland habitats in the study area vary greatly in their value to waterfowl. Marine habitats consisting of open seas and large open sounds are used primarily for resting, but Scaups and Redheads (*Aythya americana*) also feed there (Chamberlain 1960). Saltmarsh habitats — which include salt meadows, irregularly flooded *Juncus* salt marshes, regularly flooded *Spartina* salt marshes, and associated potholes, ponds, and sloughs —

may rate from insignificant to high as waterfowl habitat (USDI 1954). Generally, waterfowl usage is insignificant in large marshes that are unbroken and dominated by a single, little used plant species; usage is higher in a marsh that is broken by numerous enclosed potholes and ponds, sloughs, creeks, and tidal guts and in which several food plants are available. Usage of the mangrove swamp, dominant along areas of the Gulf Coast, is generally low but varies, depending on associated habitat types.

Freshwater rivers and streams generally are of comparatively little value to waterfowl because food-plant production is usually sparse (Chamberlain 1960). River systems that meander, creating many small, shallow lagoons and ponds, and that are heavily vegetated are important. Lakes vary greatly in value to waterfowl: those with steep sides and sand bottoms generally are of little value; but those that are broad and shallow and have extensive marshes, heavy growths of floating plants, or submerged aquatic plants may be important waterfowl areas.

Also varying in their importance to waterfowl are freshwater marshes: those dominated by dense, monotypic vegetation have negligible value; those having more open water as well as a variety of floating, emergent, and submerged plant species are of much greater value to waterfowl. Shallow marshes (wet prairies and wet meadows), which are a major wetland type in Florida, are of occasional value as waterfowl habitat.

Swamp habitats dominated by either shrub or tree vegetation are of most value to a single species, the Wood Duck. Other dabbling duck species may use temporarily flooded wooded areas.

Overall waterfowl usage of upland areas that appear to be wetlands during seasonal flooding (e.g., wooded hammocks, pine flatwoods, and improved pastures) is generally insignificant, although pastures that remain wet because of potholes or depressions and have vegetation species that are highly desirable to waterfowl may be of moderate value. Also, pastures created by draining marshes may be important if the drainage ditches contain water.

Florida's wetlands, including those in the study area, are extremely important to waterfowl, especially during the winter season. Water resource development and pollution have a tremendous influence on the area's water and wetland resources and thus the area's waterfowl populations.

6. Threatened and Endangered Species

Threatened and endangered species, including those occupying wetlands, have been discussed in preceding sections of this volume — Plants: Unique Communities; Vertebrates: Threatened and Endangered Species; and Invertebrates: Threatened and Endangered Species.

SECTION 6

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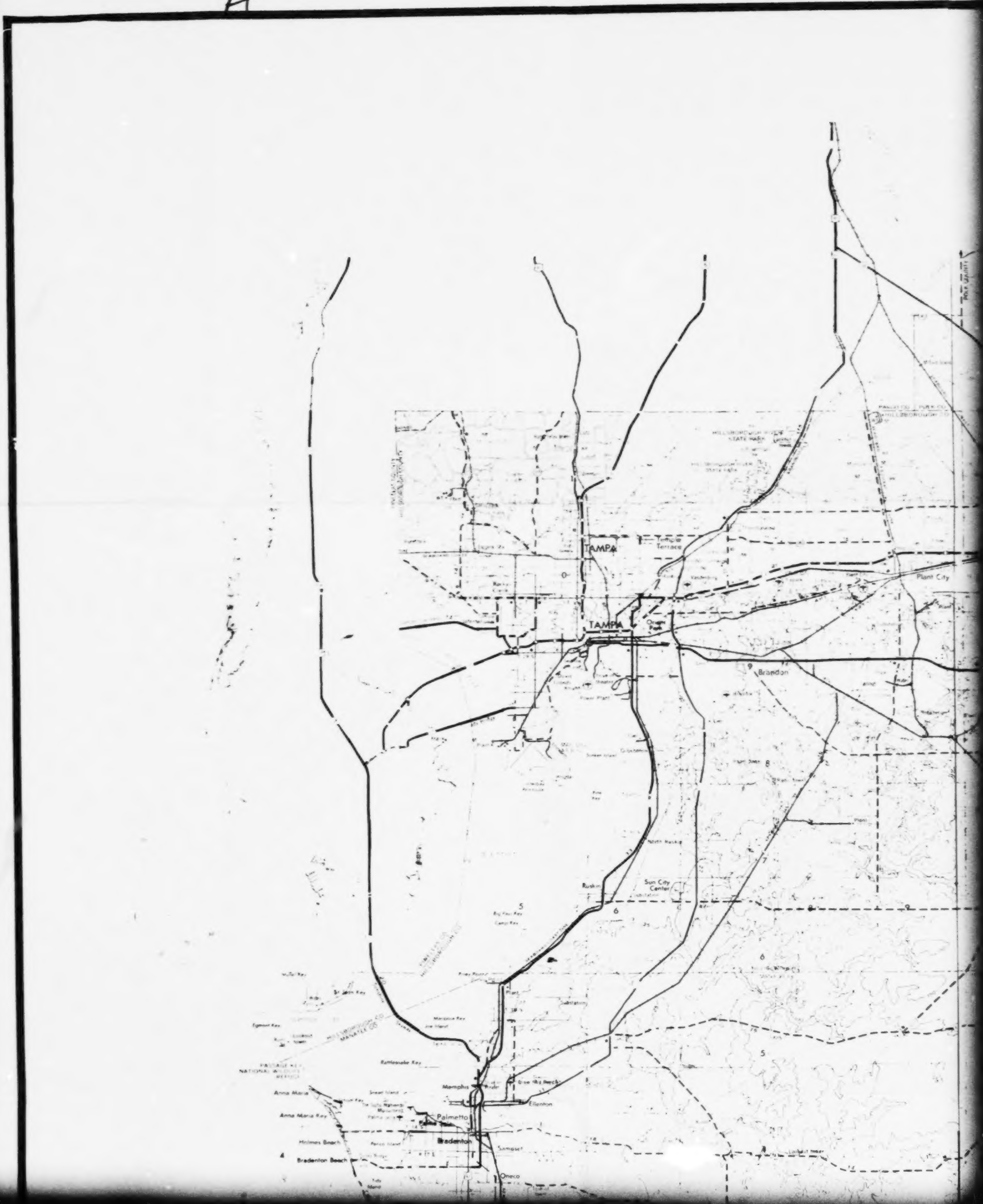
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Power Plant
Gibsonton
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North Ruskin
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Ruskin
Sun City Center
Substation
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6
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Camp Key
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HILLSBOROUGH CO.
HILLSBOROUGH CO.
MANATEE CO.
Mullet Key
St. Jean Key
Egmont Key
Lookout Island
Mariposa Key
Joe Island
Piney Point
Plant
Substation
PASSAGE KEY NATIONAL WILDLIFE REFUGE
Rattlesnake Key
Memphis
Snead Island
Anna Maria
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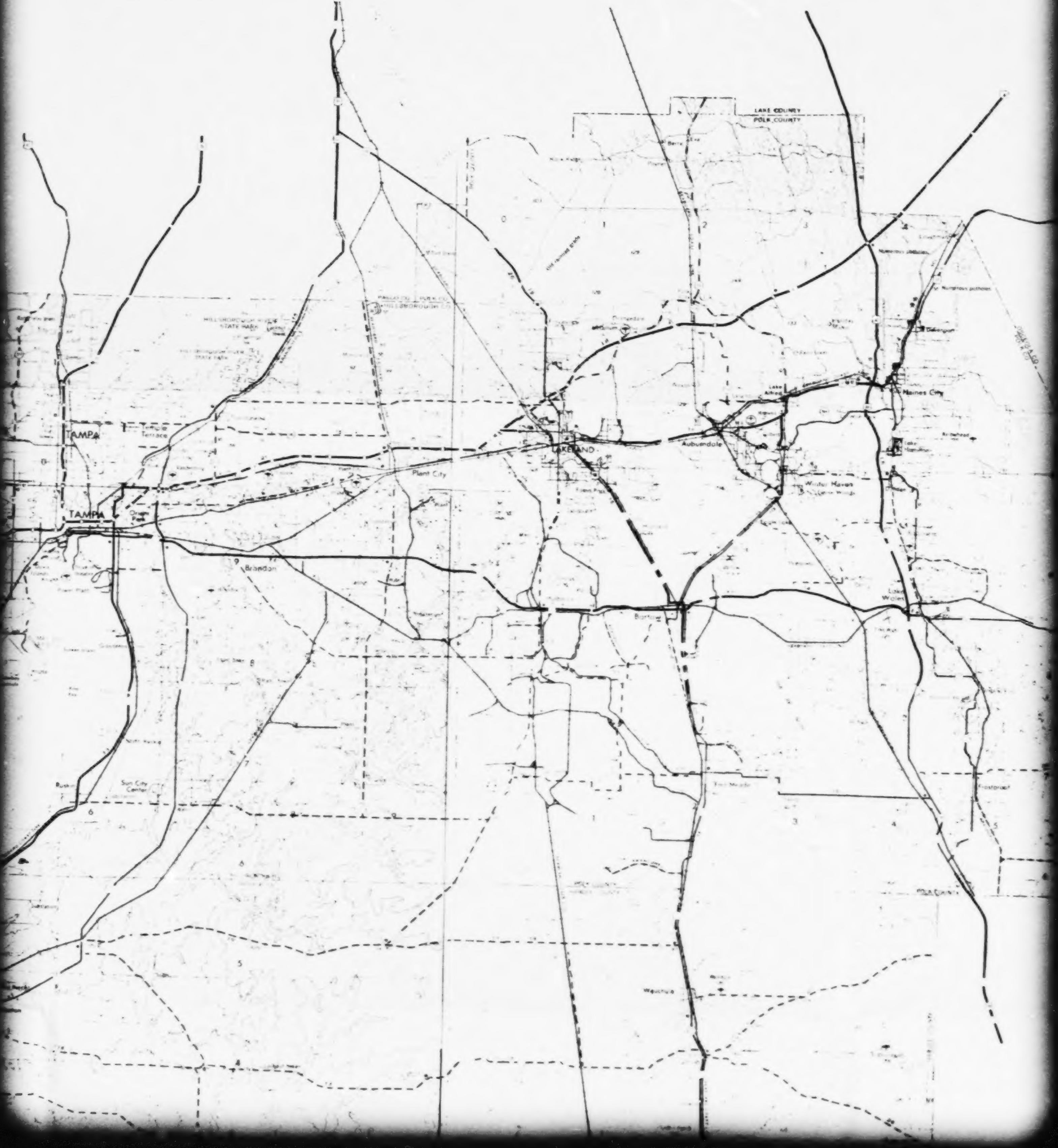
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Old railroad grade
Numerous potholes
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Auburndale
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Lake Wales
Bartow
Frostproof
Wauchula
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HILLSBOROUGH CO.
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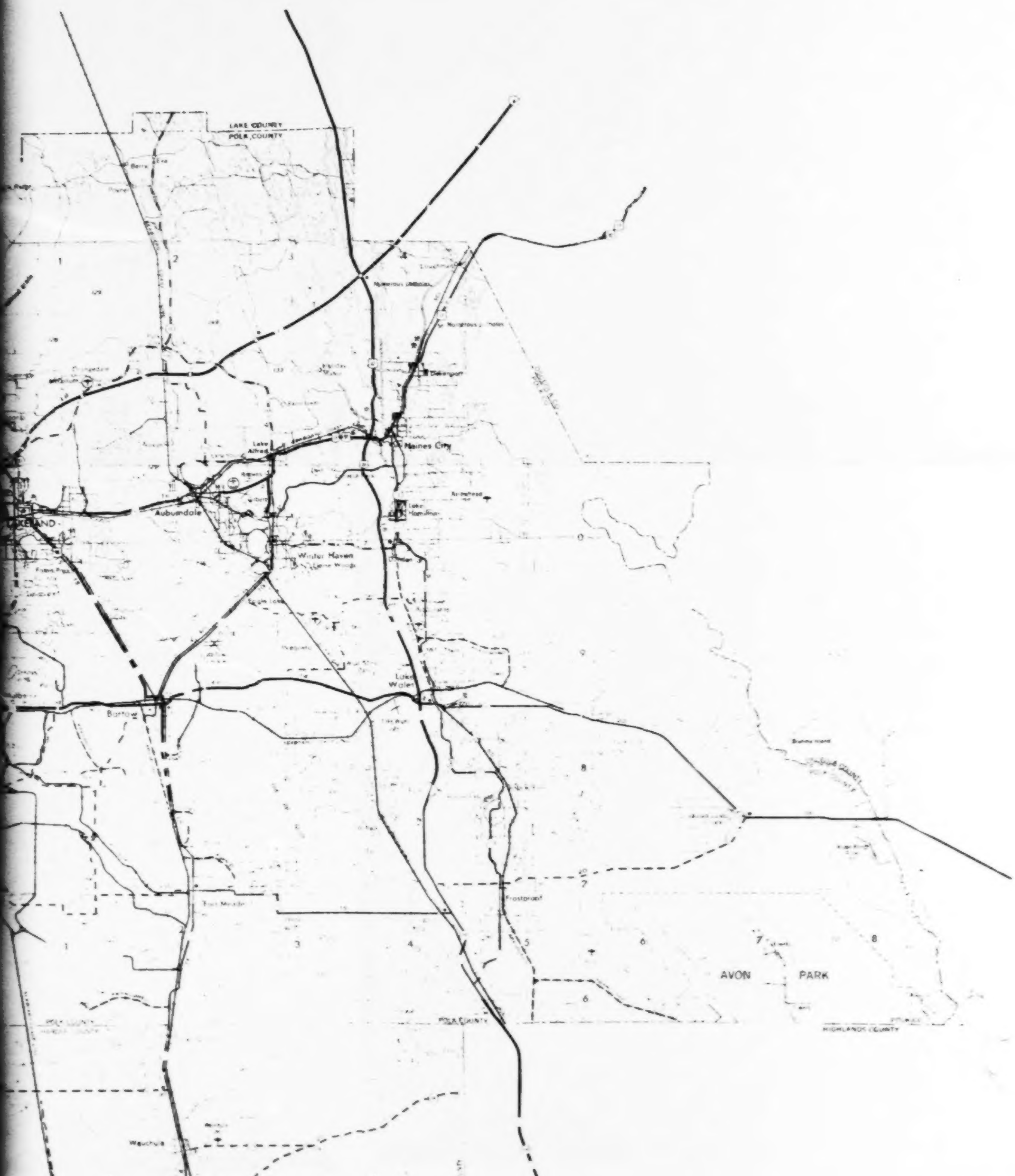
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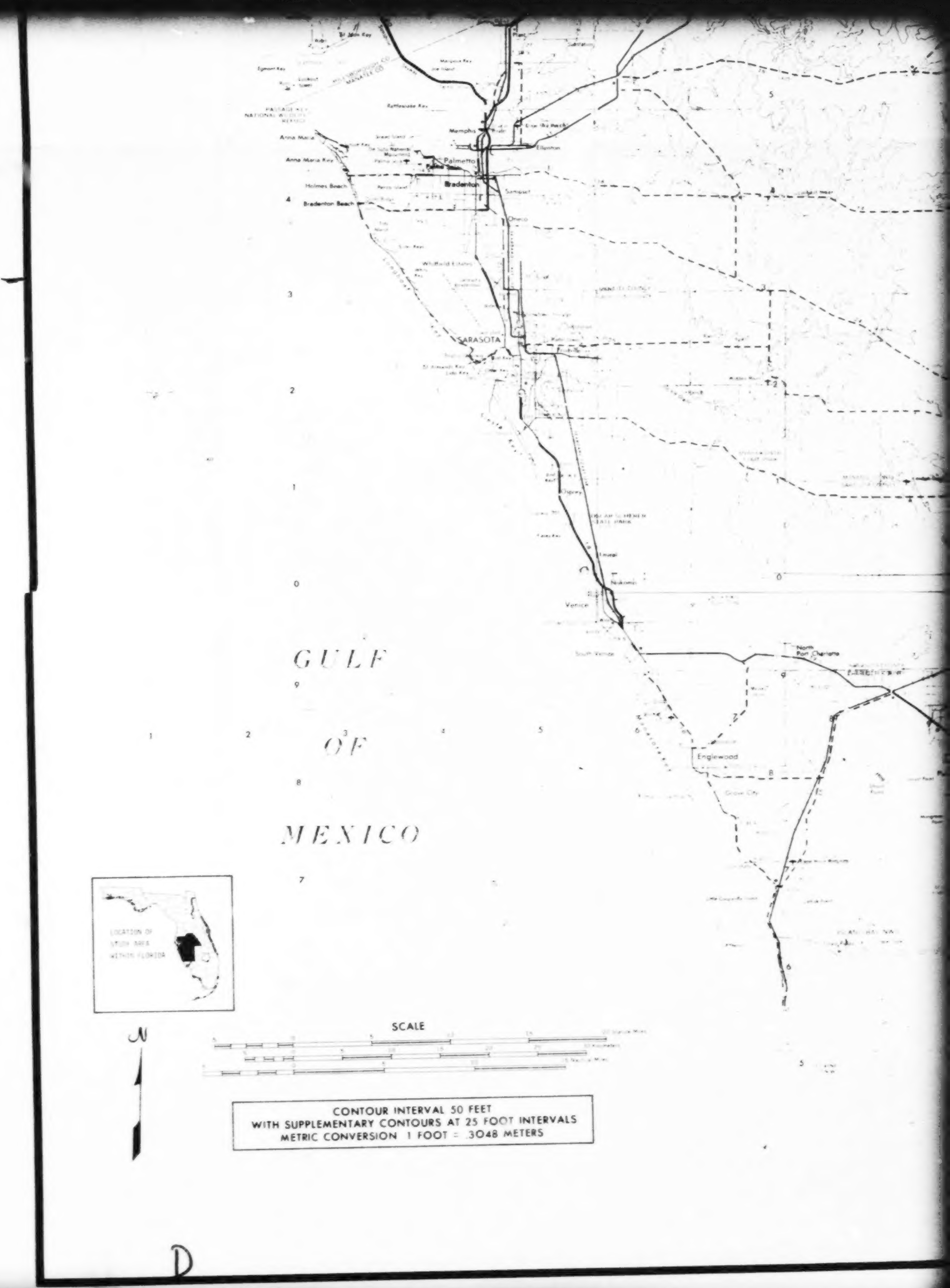
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Oneco
Whitfield Estates
SARASOTA
Osprey
Laurel
Nokomis
Venice
South Venice
North Port Charlotte
Englewood
Grove City
GULF OF MEXICO
LOCATION OF STUDY AREA WITHIN FLORIDA
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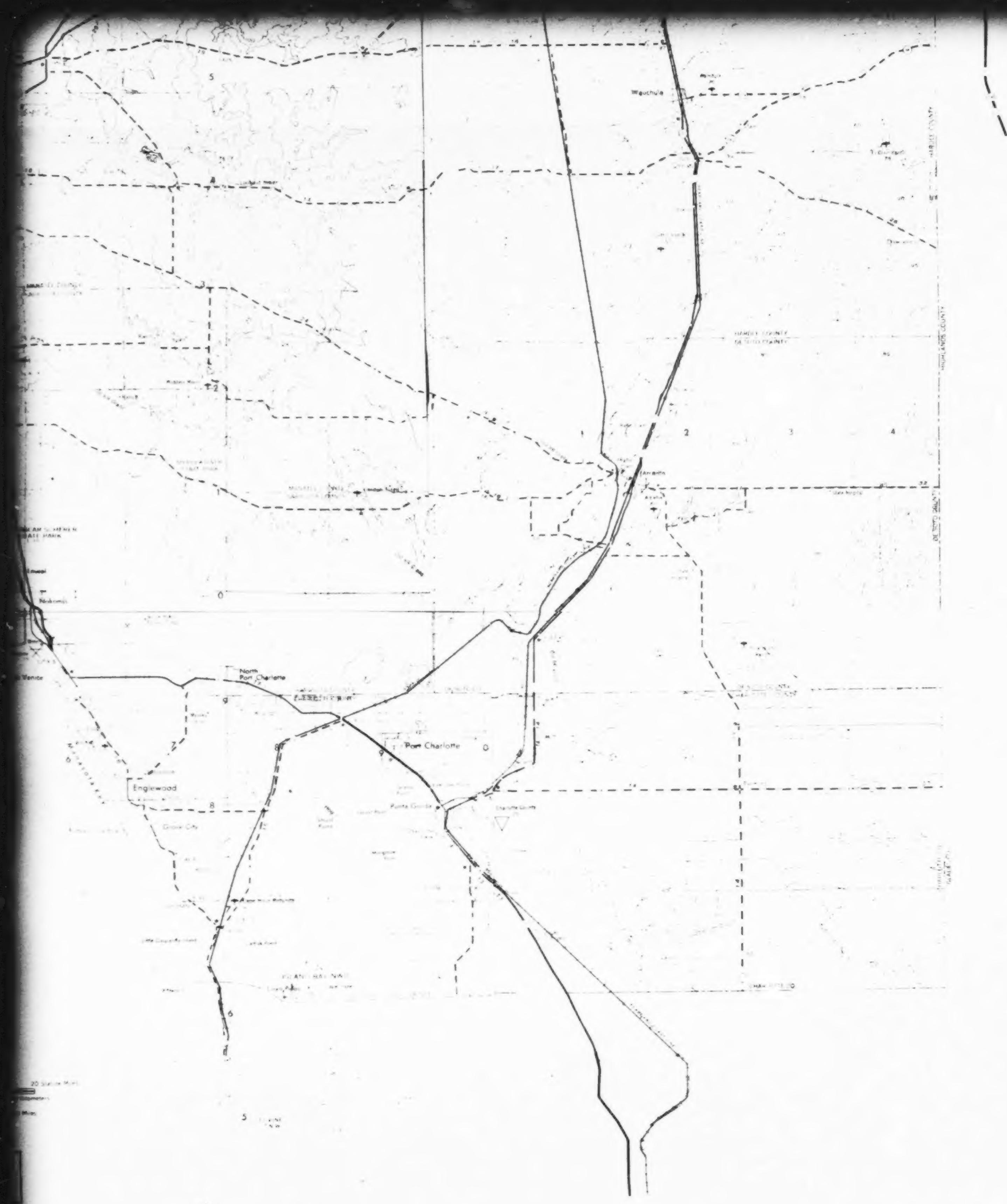
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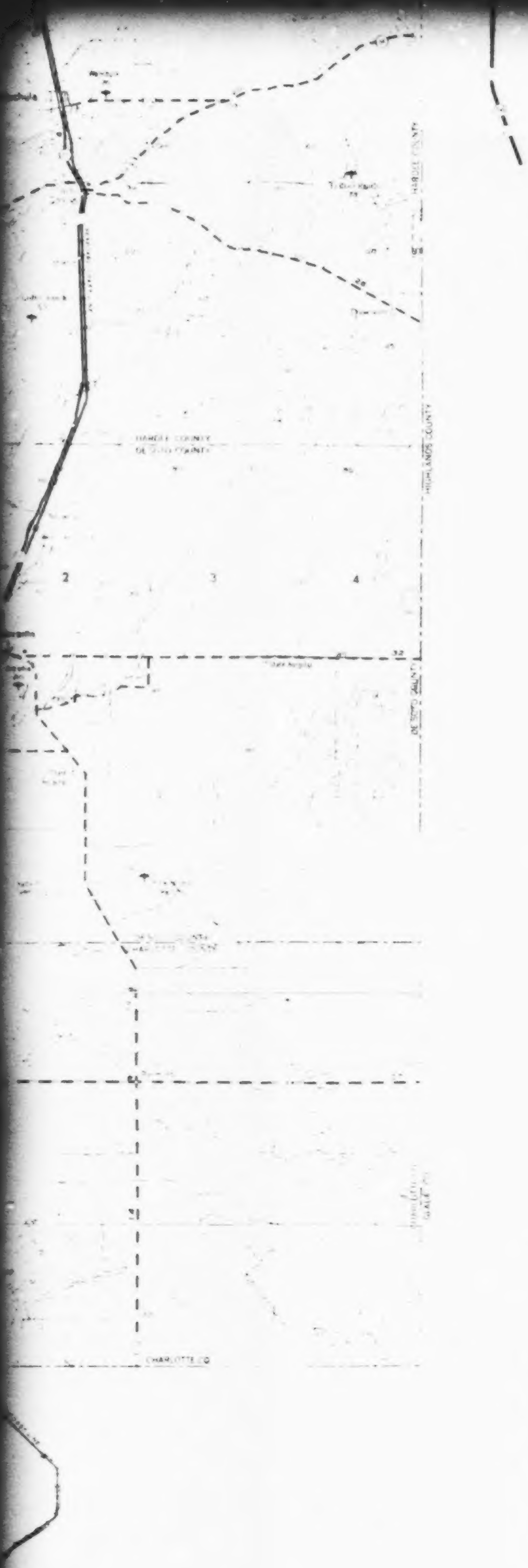
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CENTRAL FLORIDA PHOSPHATE EIS

PLATE I - Volume VI

TOPOGRAPHY AND CULTURAL FEATURES

Prepared by

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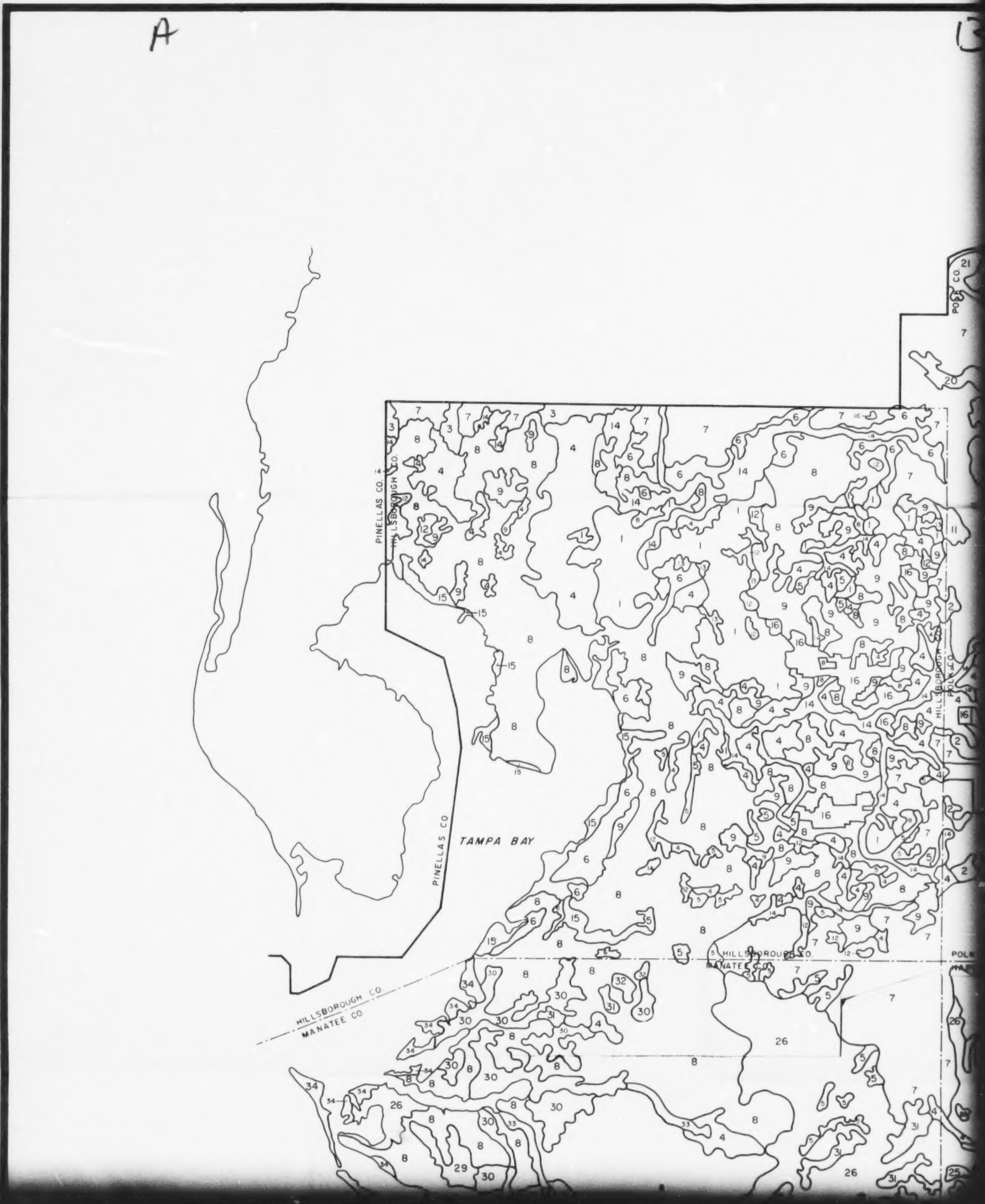
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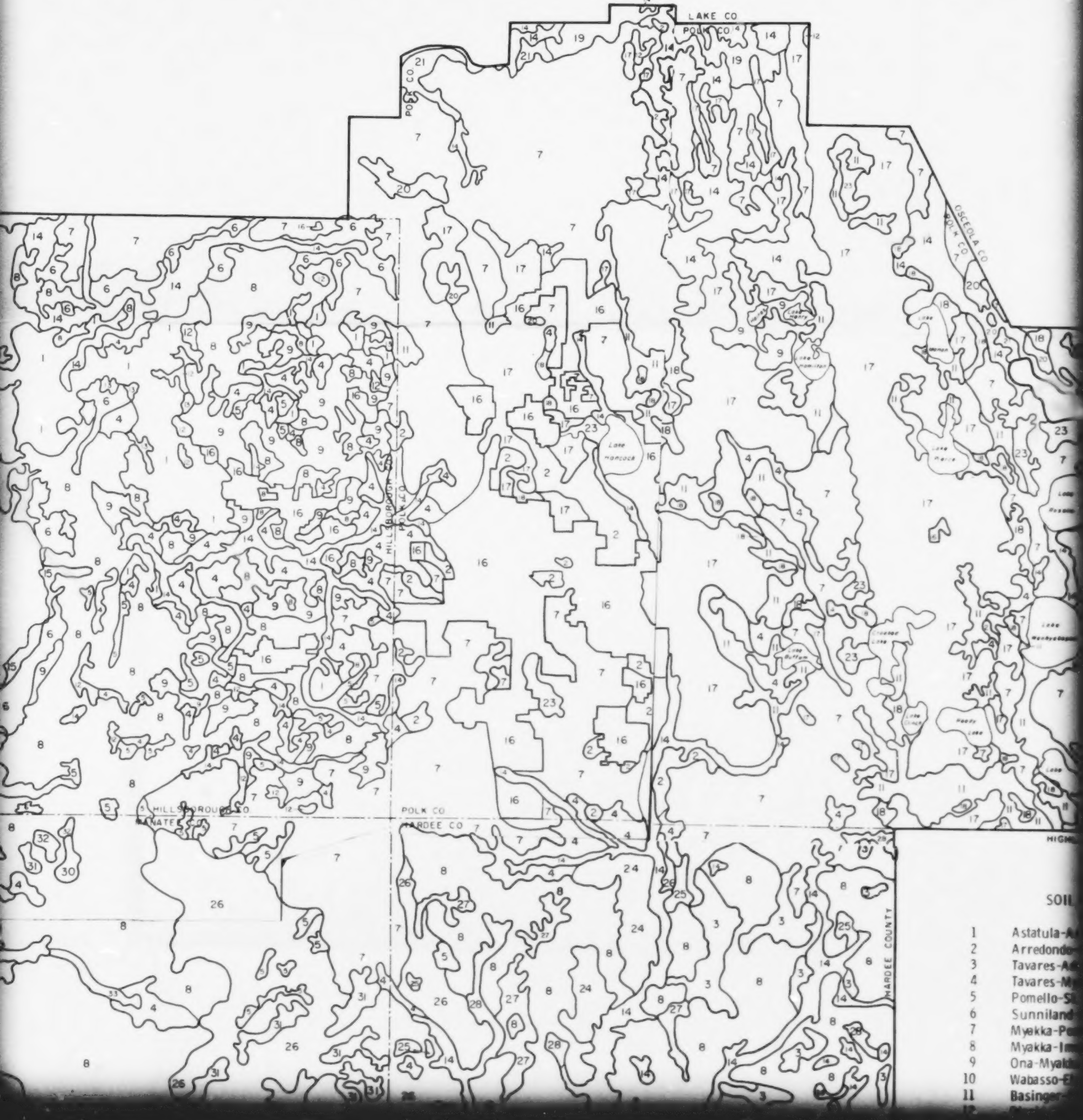
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Lake Weohyakapka
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SOIL
1 Astatula-
2 Arredondo-
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10 Wabasso-
11 Basinger-

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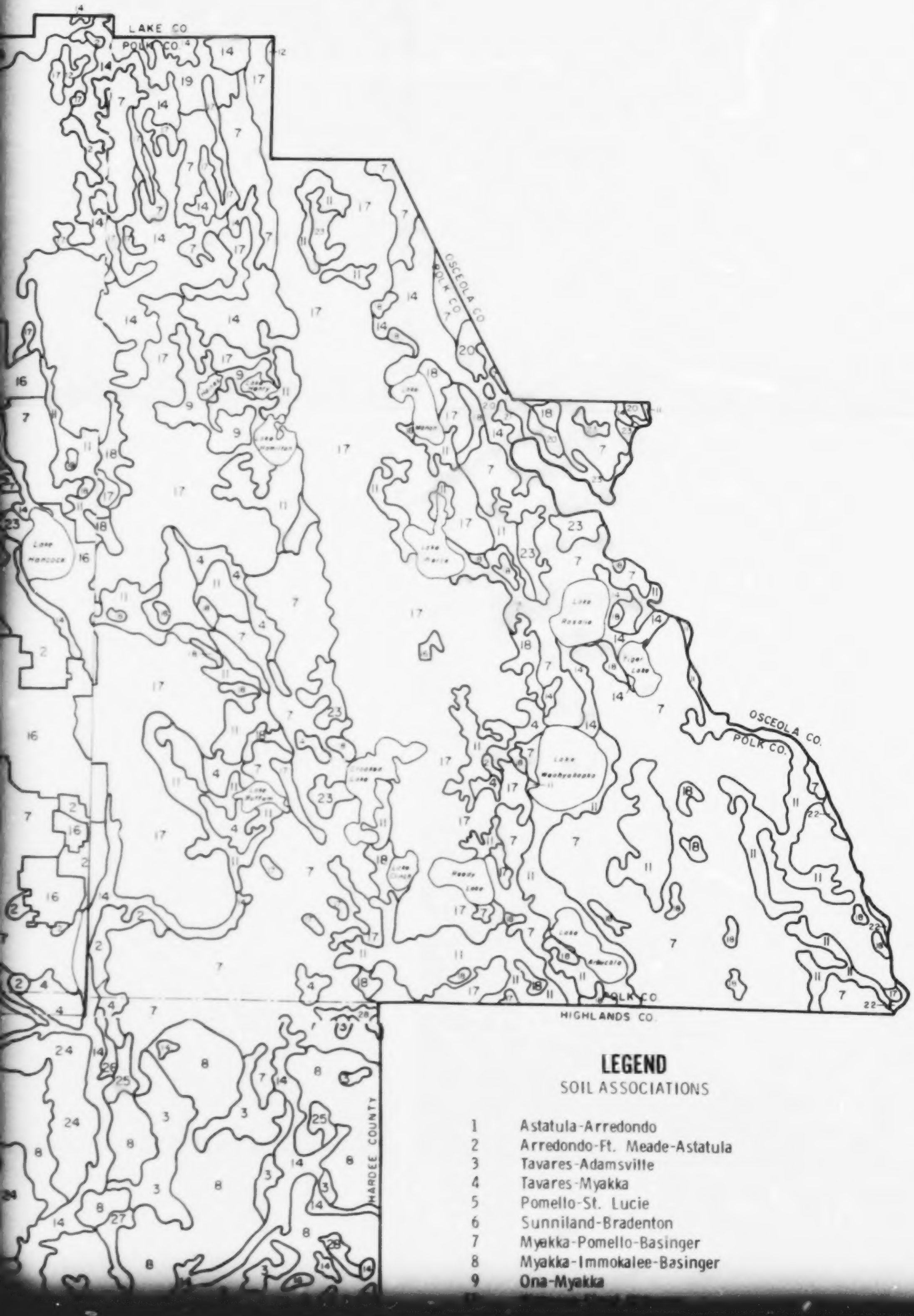
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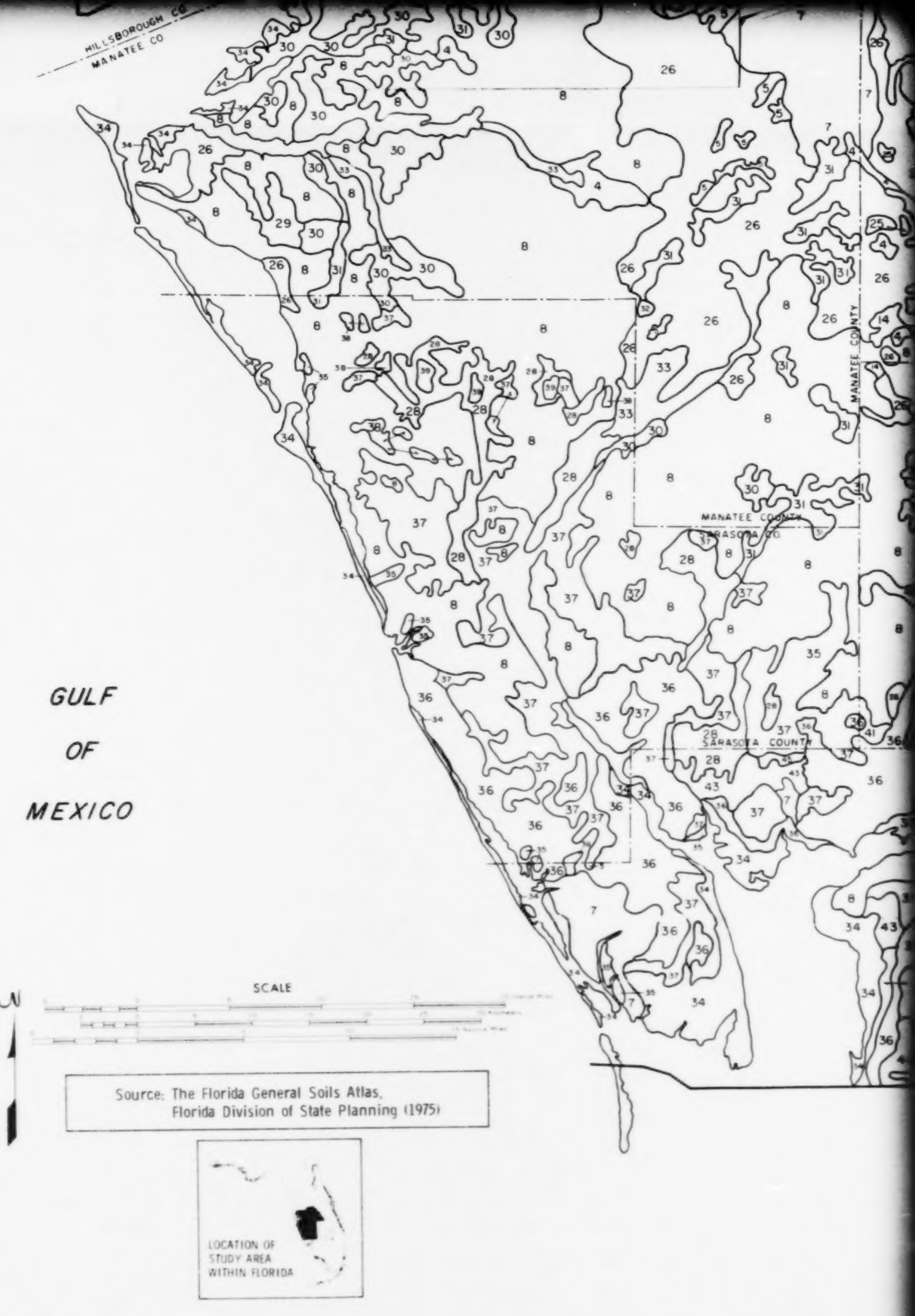
Lake Pierce
Lake Rosalie
Tiger Lake
Lake Weohyakapka
Crooked Lake
Lake Buffum
Reedy Lake
Lake Arbuckle

LEGEND

SOIL ASSOCIATIONS

1	Astatula-Arredondo
2	Arredondo-Ft. Meade-Astatula
3	Tavares-Adamsville
4	Tavares-Myakka
5	Pomello-St. Lucie
6	Sunniland-Bradenton
7	Myakka-Pomello-Basinger
8	Myakka-Immokalee-Basinger
9	**Ona-Myakka**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LOCATION OF STUDY AREA WITHIN FLORIDA

Source: The Florida General Soils Atlas,
Florida Division of State Planning (1975)

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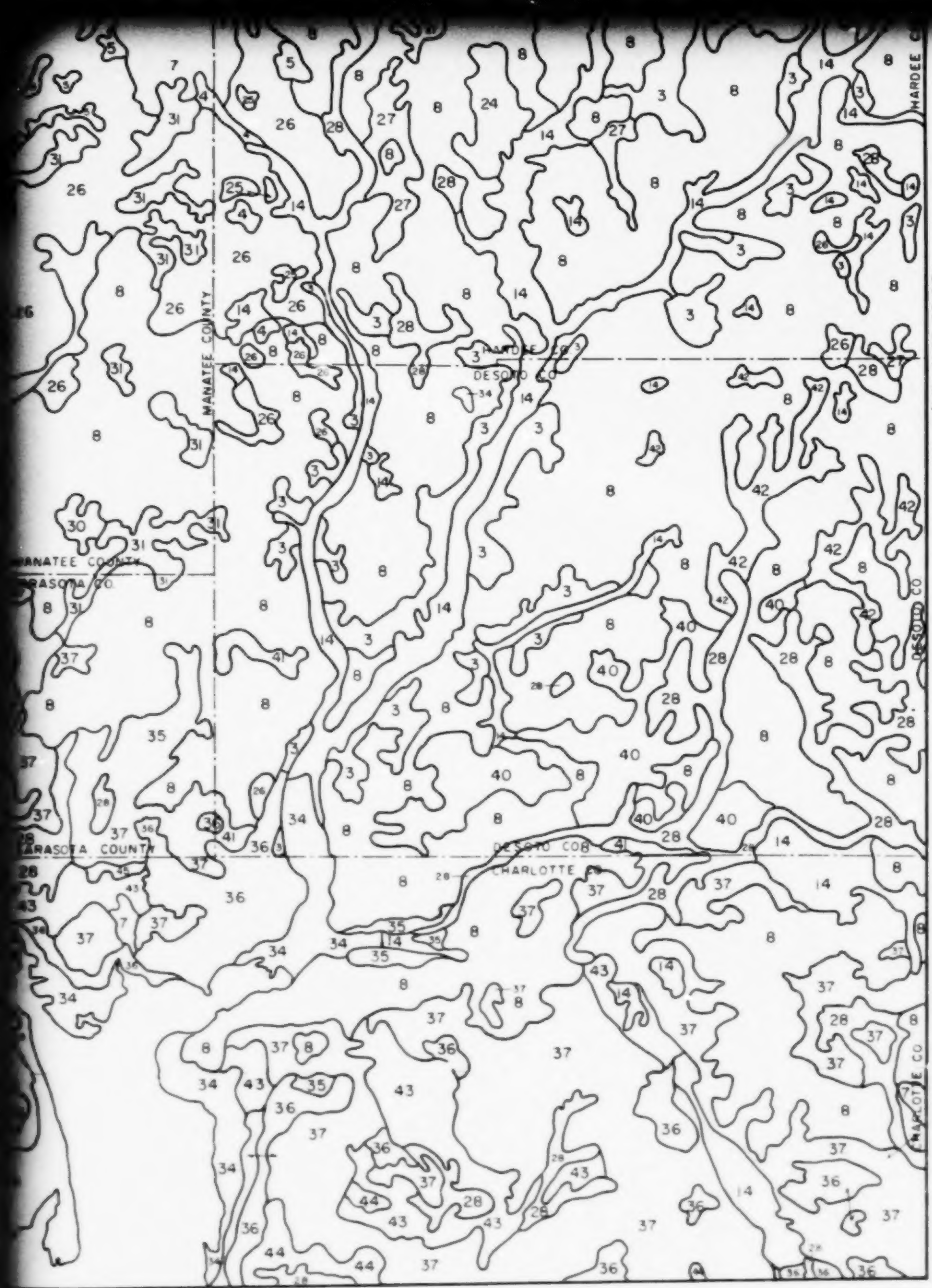
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2	**Arredondo-Ft. Meade-Astatula**
3	Tavares-Adamsville
4	Tavares-Myakka
5	Pomello-St. Lucie
6	Sunniland-Bradenton
7	Myakka-Pomello-Basinger
8	Myakka-Immokalee-Basinger
9	Ona-Myakka
10	Wabasso-Elred-Oldsmar
11	Basinger-Pompano-Swamp
12	Placid-Swamp
13	Brighton-Terra Ceia
14	Fresh Water Swamp
15	Salt Water Swamps & Marshes
16	Mine Pits & Dumps
17	Astatula-Tavares-Basinger
18	Pomello-Basinger-St. Lucie
19	Myakka-Placid-Swamp
20	Felda-Pompano-Wabasso
21	Paisley-Bushnell
22	Chobee-Delray
23	Brighton-Placid
24	Candler-Tavares
25	Pomello-Myakka-Tavares
26	Immokalee-Pomello
27	Wabasso-Felda
28	Pompano-Charlotte-Delray
29	Broward-Bradenton-Manatee
30	Wabasso-Bradenton-Myakka
31	Placid-Basinger
32	Delray-Manatee-Pompano
33	Fresh Water Swamp & Marsh
34	Tidal Marsh & Swamp-Coastal Beach Ridges
35	Pomello-Paola-St. Lucie
36	Immokalee-Myakka-Pompano
37	Adamsville-Pompano
38	Scranton, var. -Ona-Placid
39	Terra Ceia
40	Pompano, high-Felda
41	Pompano, high-Pompano
42	Basinger-Placid
43	Bradenton-Wabasso-Felda
44	Keri-Ft. Drum-Hallandale
45	Felda-Manatee

CENTRAL FLORIDA PHOSPH

PLATE 2 - Volume VI

SOIL ASSOCIATION

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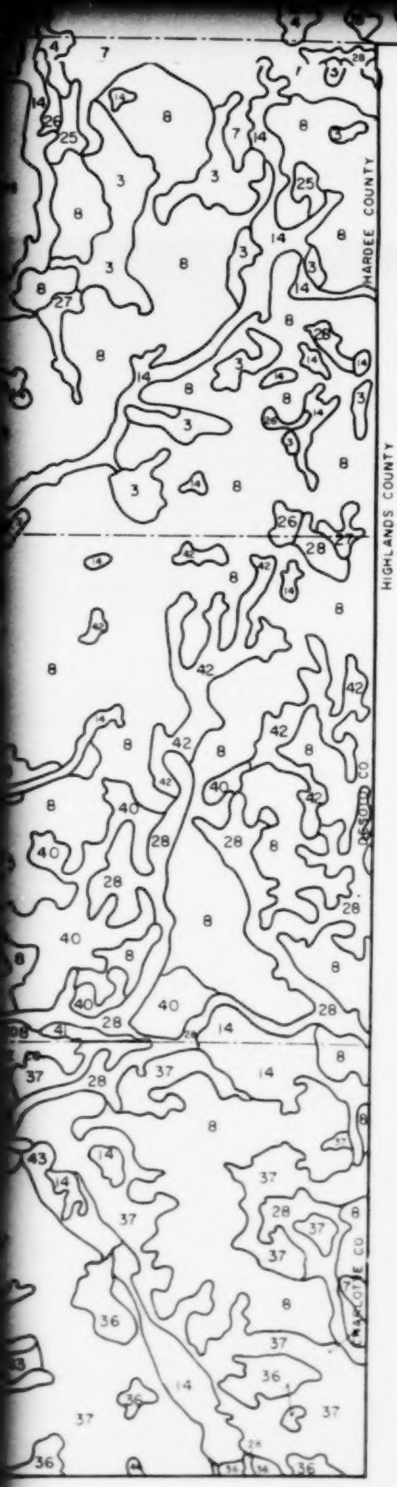

LEGEND

SOIL ASSOCIATIONS

1	Astatula-Arredondo
2	Arredondo-Ft. Meade-Astatula
3	Tavares-Adamsville
4	Tavares-Myakka
5	Pomello-St. Lucie
6	Sunniland-Bradenton
7	Myakka-Pomello-Basinger
8	Myakka-Immokalee-Basinger
9	Ona-Myakka
10	Wabasso-Elred-Oldsmar
11	Basinger-Pompano-Swamp
12	Placid-Swamp
13	Brighton-Terra Ceia
14	Fresh Water Swamp
15	Salt Water Swamps & Marshes
16	Mine Pits & Dumps
17	Astatula-Tavares-Basinger
18	Pomello-Basinger-St. Lucie
19	Myakka-Placid-Swamp
20	Felda-Pompano-Wabasso
21	Paisley-Bushnell
22	Chobee-Delray
23	Brighton-Placid
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25	Pomello-Myakka-Tavares
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27	Wabasso-Felda
28	Pompano-Charlotte-Delray
29	Broward-Bradenton-Manatee
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35	Pomello-Paola-St. Lucie
36	Immokalee-Myakka-Pompano
37	Adamsville-Pompano
38	Scranton, var. -Ona-Placid
39	Terra Ceia
40	Pompano, high-Felda
41	Pompano, high-Pompano
42	Basinger-Placid
43	Bradenton-Wabasso-Felda
44	Keri-Ft. Drum-Hallandale
45	Felda-Manatee

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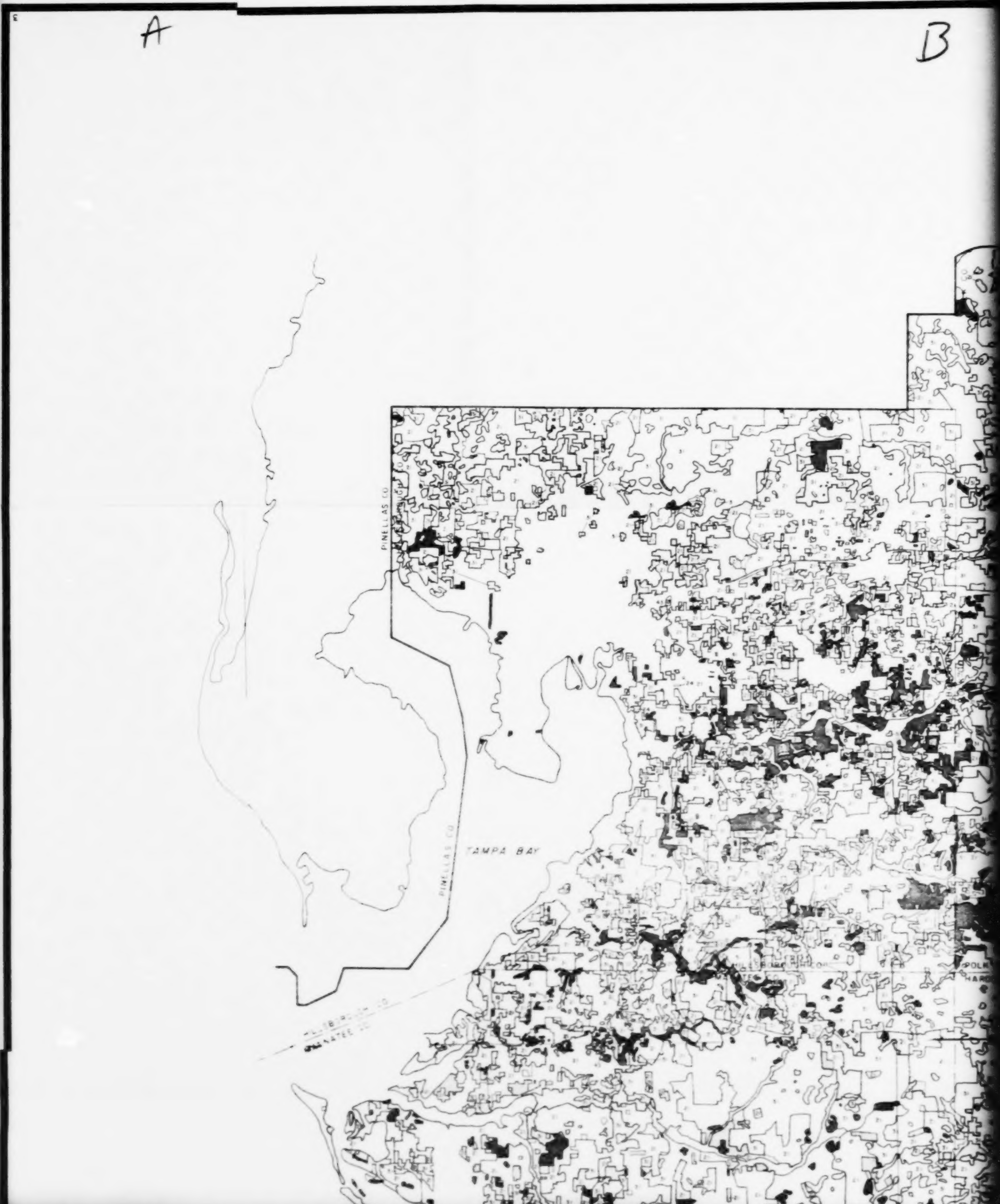
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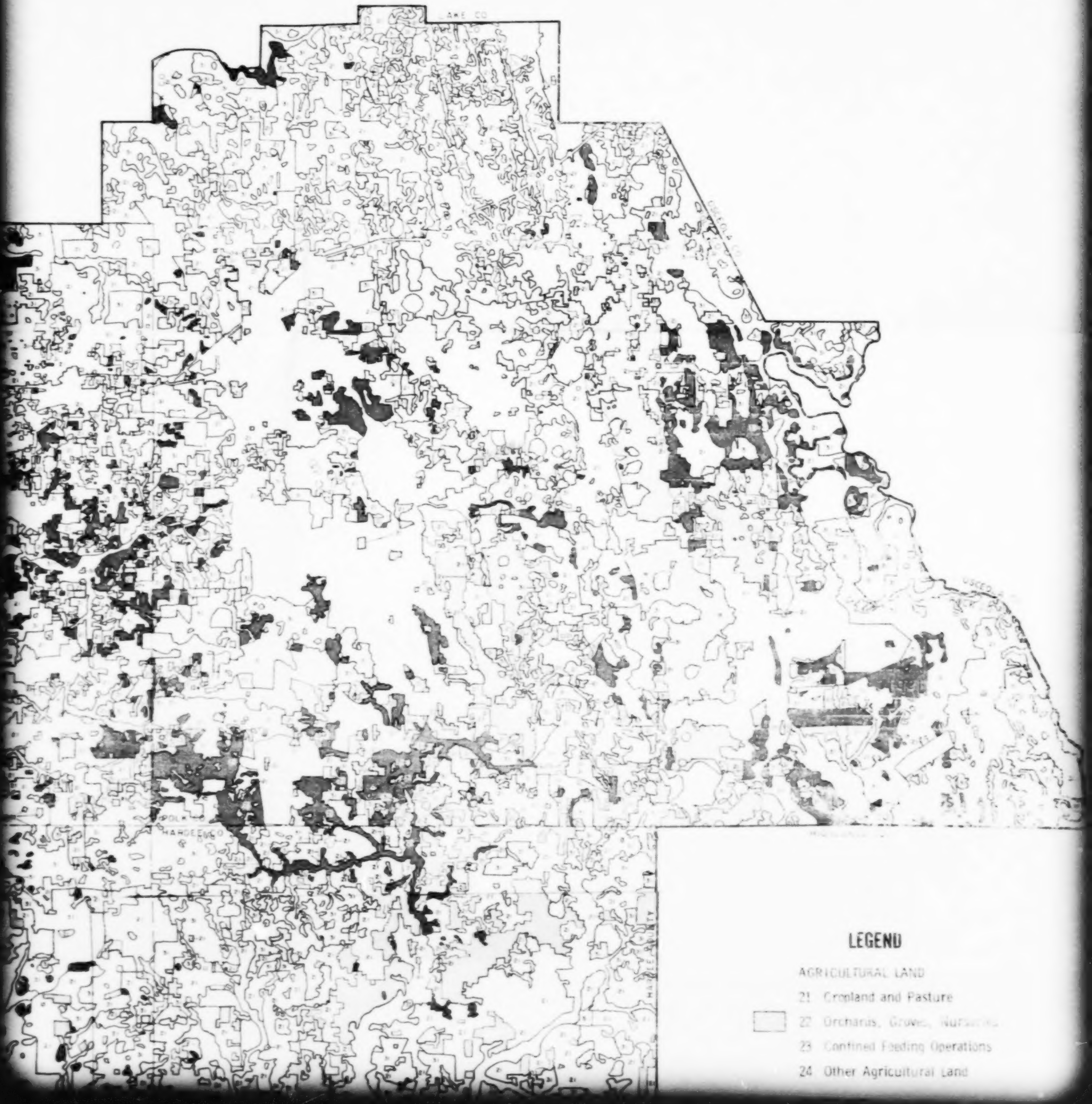
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22 Orchards, Groves, Nurseries
23 Confined Feeding Operations
24 Other Agricultural Land

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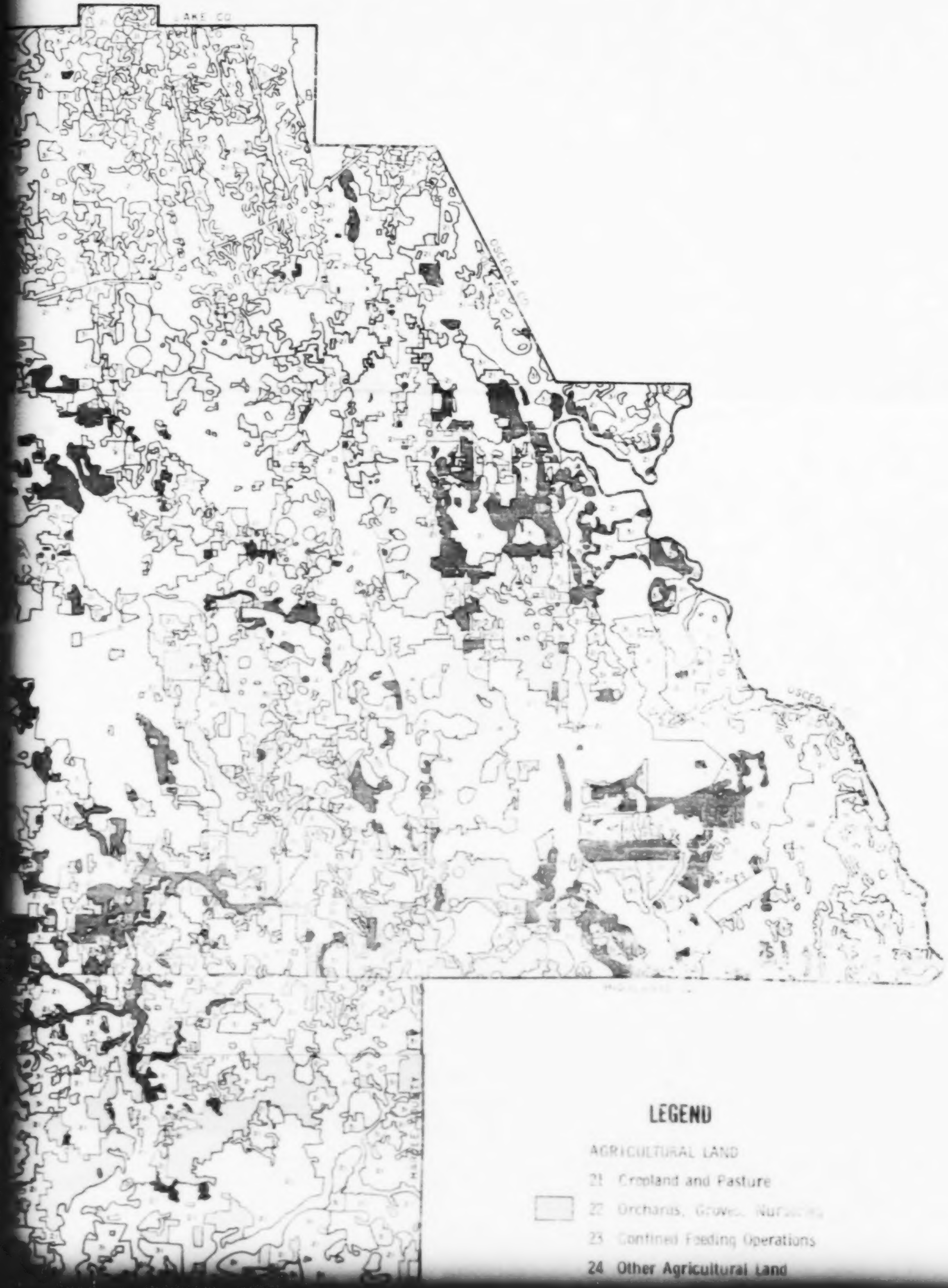
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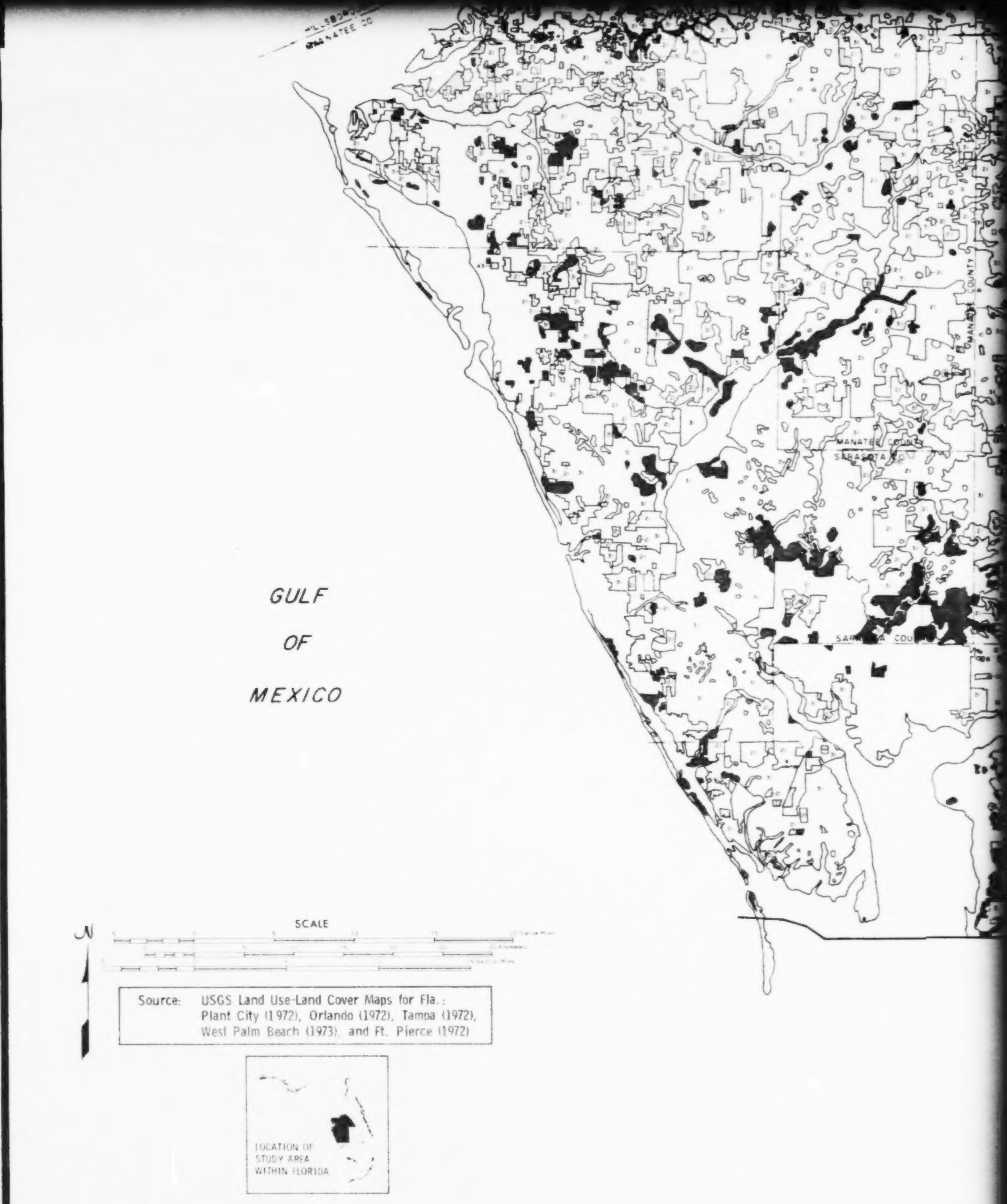
24 Other Agricultural Land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LOCATION OF
STUDY AREA
WITHIN FLORIDA

Source: USGS Land Use-Land Cover Maps for Fla.: Plant City (1972), Orlando (1972), Tampa (1972), West Palm Beach (1973), and Ft. Pierce (1972)

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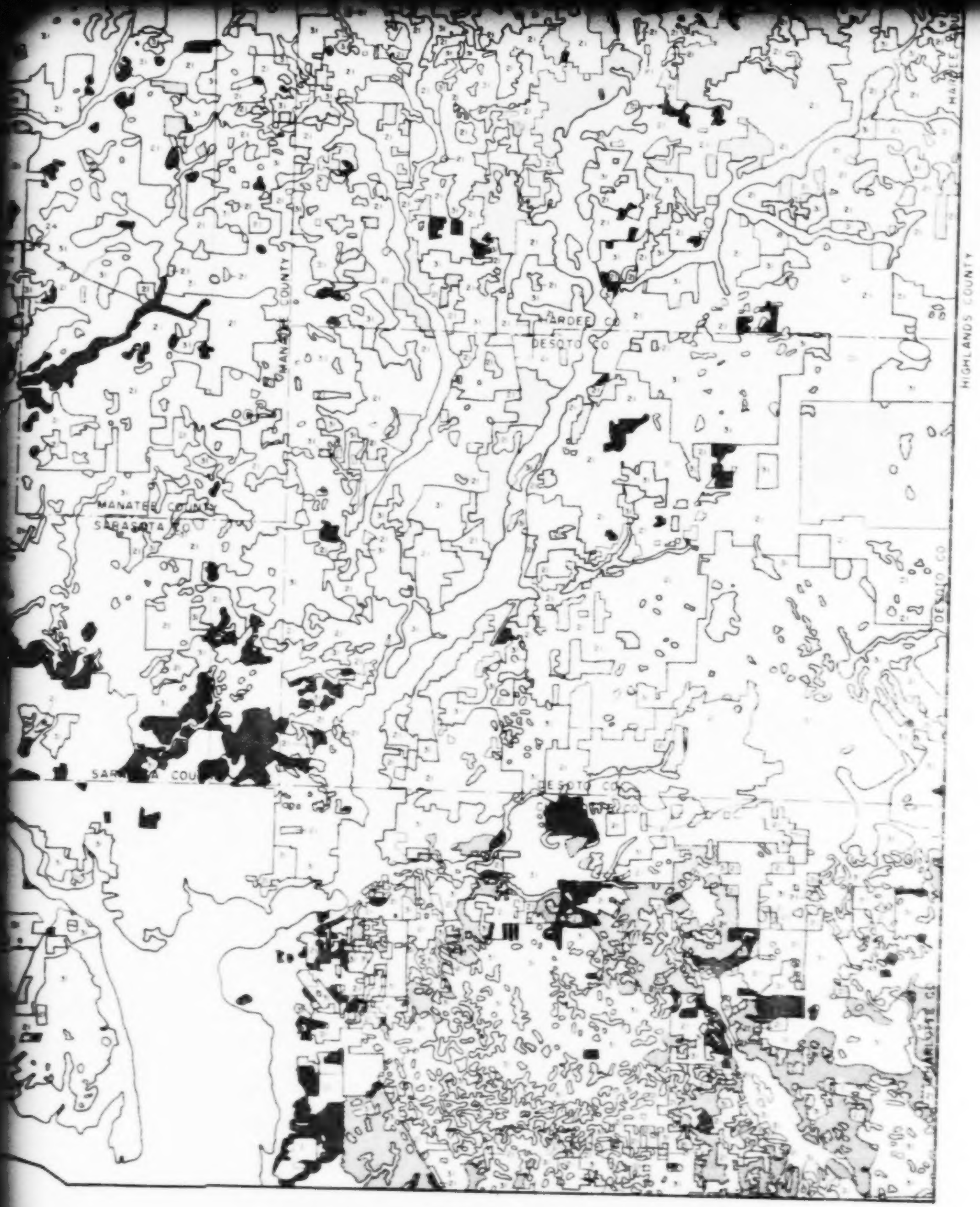
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LEGEND

AGRICULTURAL LAND

21 Cropland and Pasture
☐ 22 Orchards, Groves, Nurseries
23 Confined Feeding Operations
24 Other Agricultural Land

RANGELAND

31 Herbaceous Rangeland
32 Shrub and Brush Rangeland
▨ 33 Mixed Rangeland

FOREST LAND

41 Deciduous Forest Land
■ 42 Evergreen Forest Land
43 Mixed Forest Land

CENTRAL FLORIDA PH

EXISTING LAND

PLATE 3 Volume VI

Prepared by

TEXAS INSTRUME

EPA Contract Number 68-

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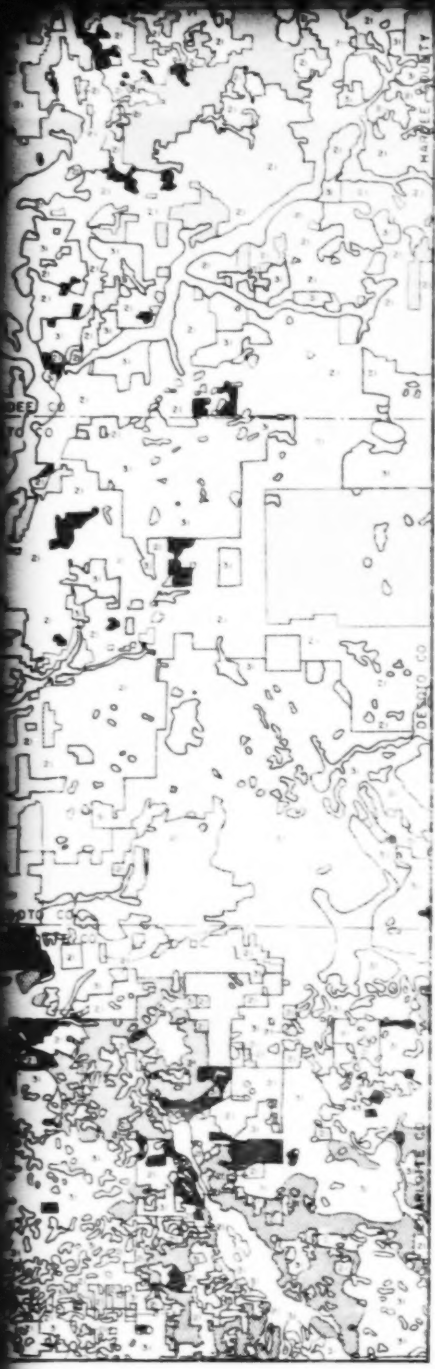
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LEGEND

AGRICULTURAL LAND

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RANGELAND

31 Herbaceous Rangeland

32 Shrub and Brush Rangeland

░ 33 Mixed Rangeland

FOREST LAND

41 Deciduous Forest Land

■ 42 Evergreen Forest Land

43 Mixed Forest Land

CENTRAL FLORIDA PHOSPHATE EIS

EXISTING LAND USE I

PLATE 3 Volume VI

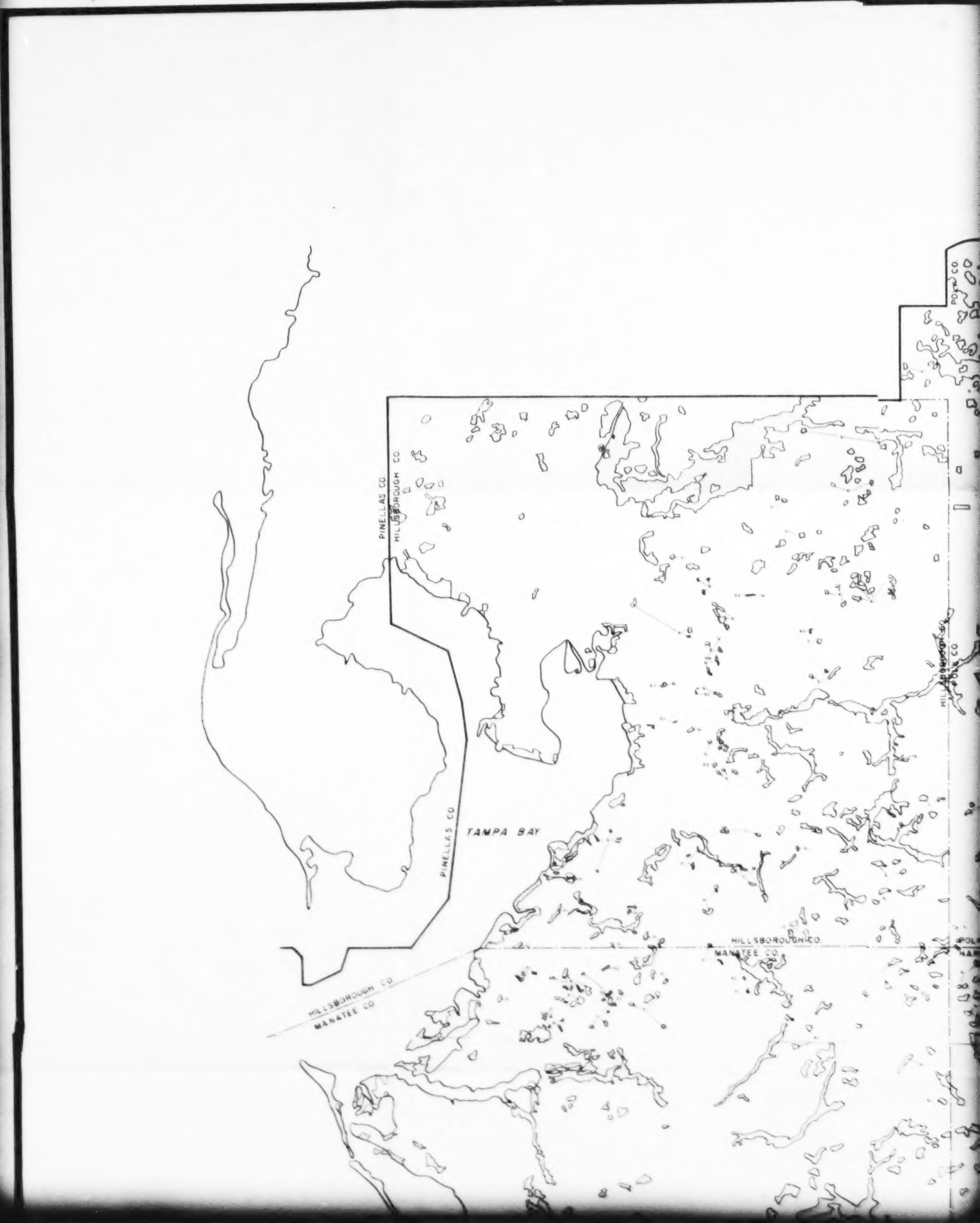
Prepared by

TEXAS INSTRUMENTS

EPA Contract Number 68-01-4196

F

A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HILLSBOROUGH CO.
TAMPA BAY
PINELLAS CO
HILLSBOROUGH CO.
MANATEE CO.
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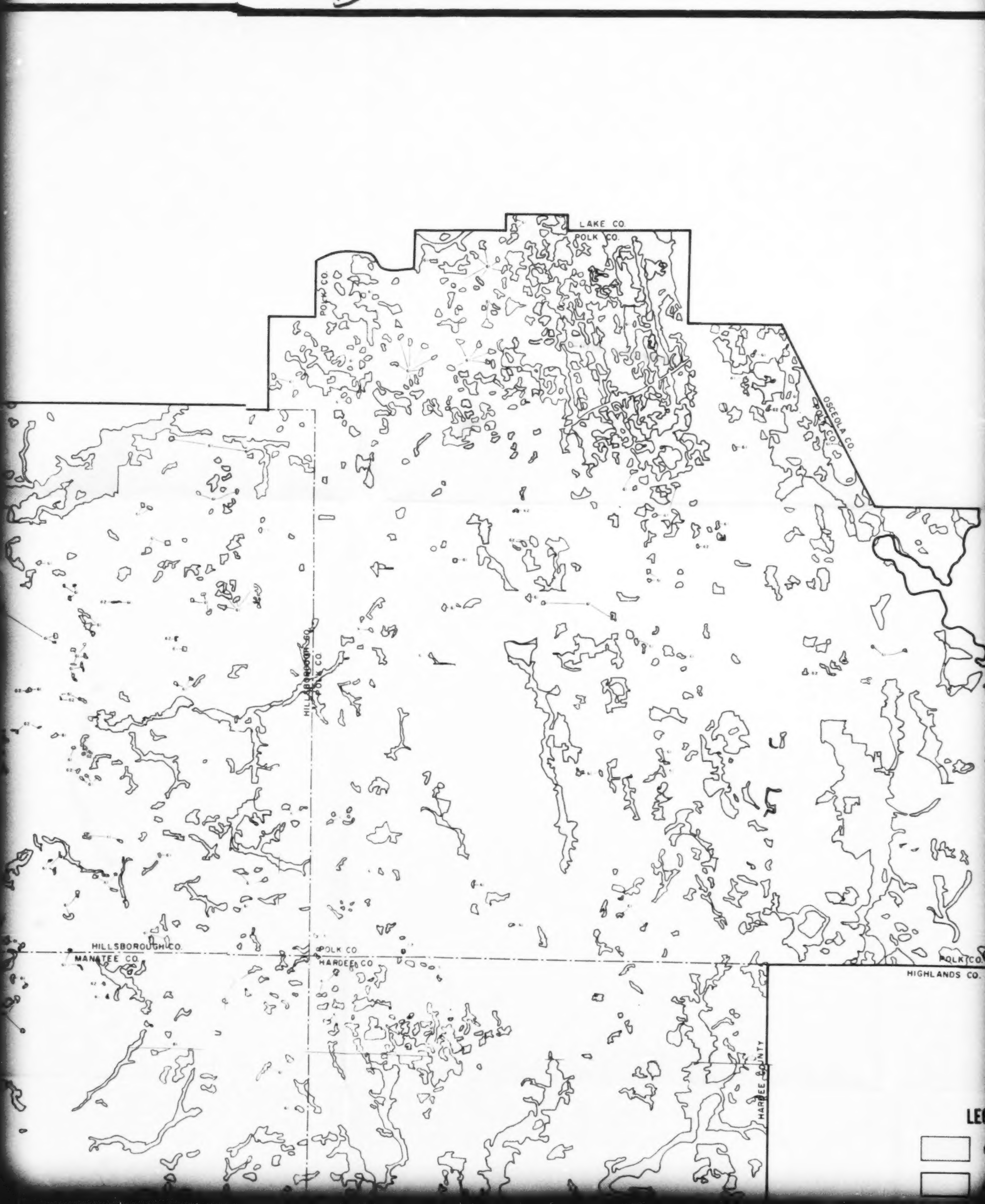
MANATEE CO.
HILLSBOROUGH CO.
POLK CO.
POLK CO.

B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POLK CO.
POLK CO.
OSCEOLA CO.
HILLSBOROUGH CO.
POLK CO.
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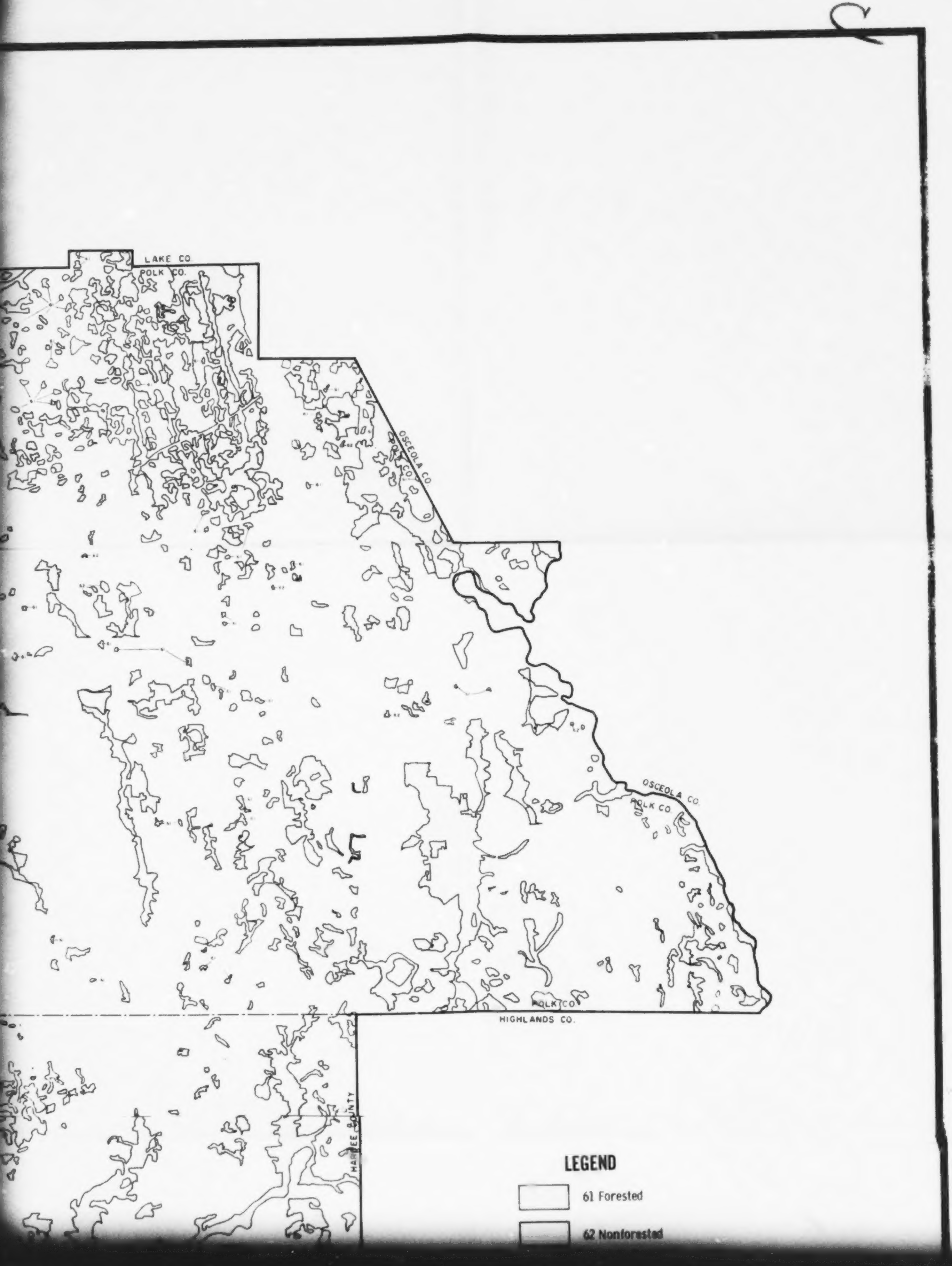
MANATEE CO.
POLK CO.
HARDEE CO.
POLK CO.
HIGHLANDS CO.
HARDEE COUNTY
LE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POLK CO.
OSCEOLA CO.
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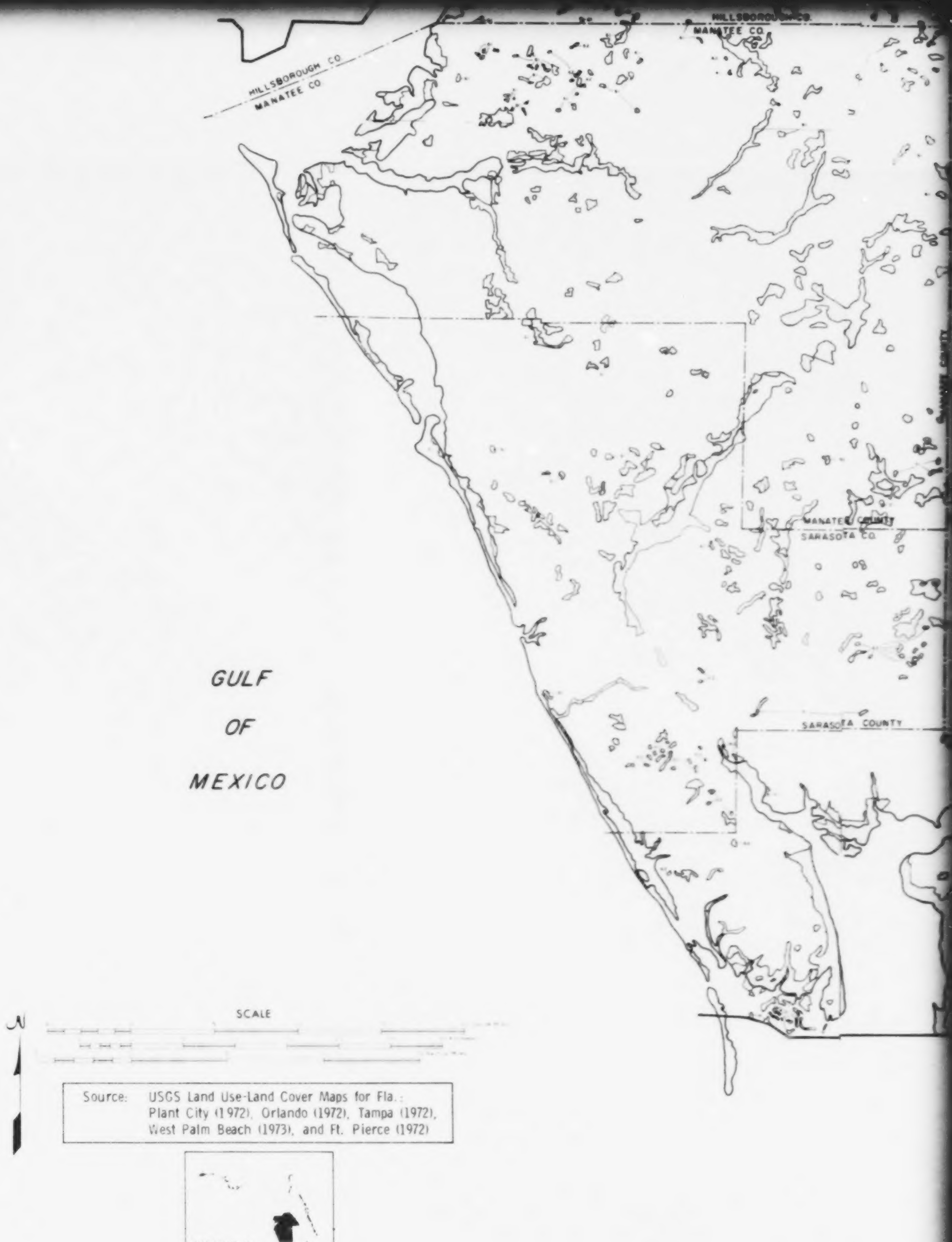
OSCEOLA CO.
POLK CO.
POLK CO.
HIGHLANDS CO.
HARDEE COUNTY
LEGEND
61 Forested
62 Nonforested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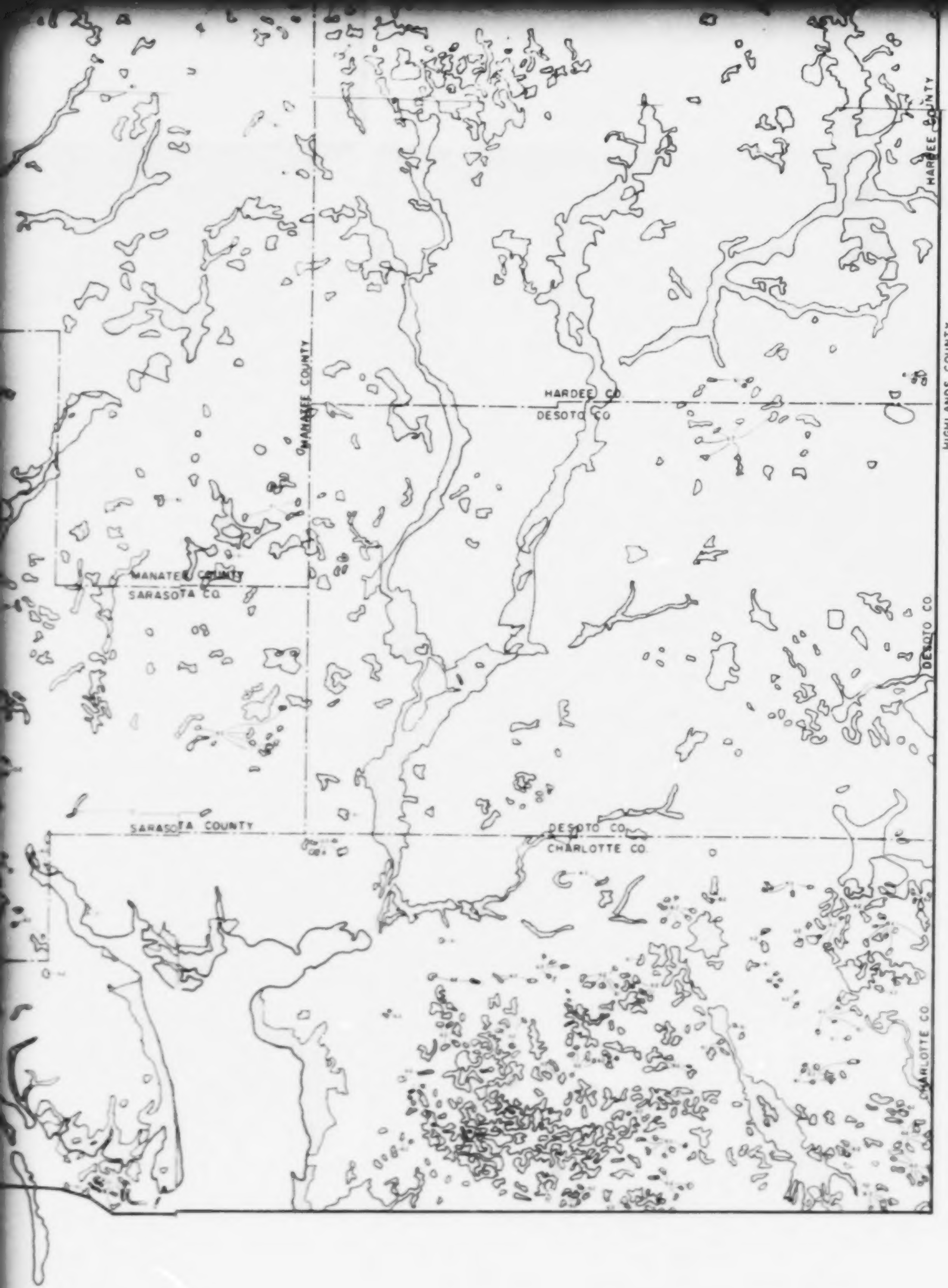
MANATEE CO.
HILLSBOROUGH CO.
MANATEE CO.
GULF
OF
MEXICO
MANATEE COUNTY
SARASOTA CO.
SARASOTA COUNTY
SCALE
N
LOCATION OF
STUDY AREA
WITHIN FLORIDA

Source: USGS Land Use-Land Cover Maps for Fla.:
Plant City (1972), Orlando (1972), Tampa (1972),
West Palm Beach (1973), and Ft. Pierce (1972)

D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HARDEE CO
DESOTO CO
MANATEE COUNTY
HIGHLANDS COUNTY
MANATEE COUNTY
SARASOTA CO
DESOTO CO
SARASOTA COUNTY
DESOTO CO
CHARLOTTE CO
CHARLOTTE CO

LEGEND

☐ 61 Forested

☐ 62 Nonforested

CENTRAL FLORIDA

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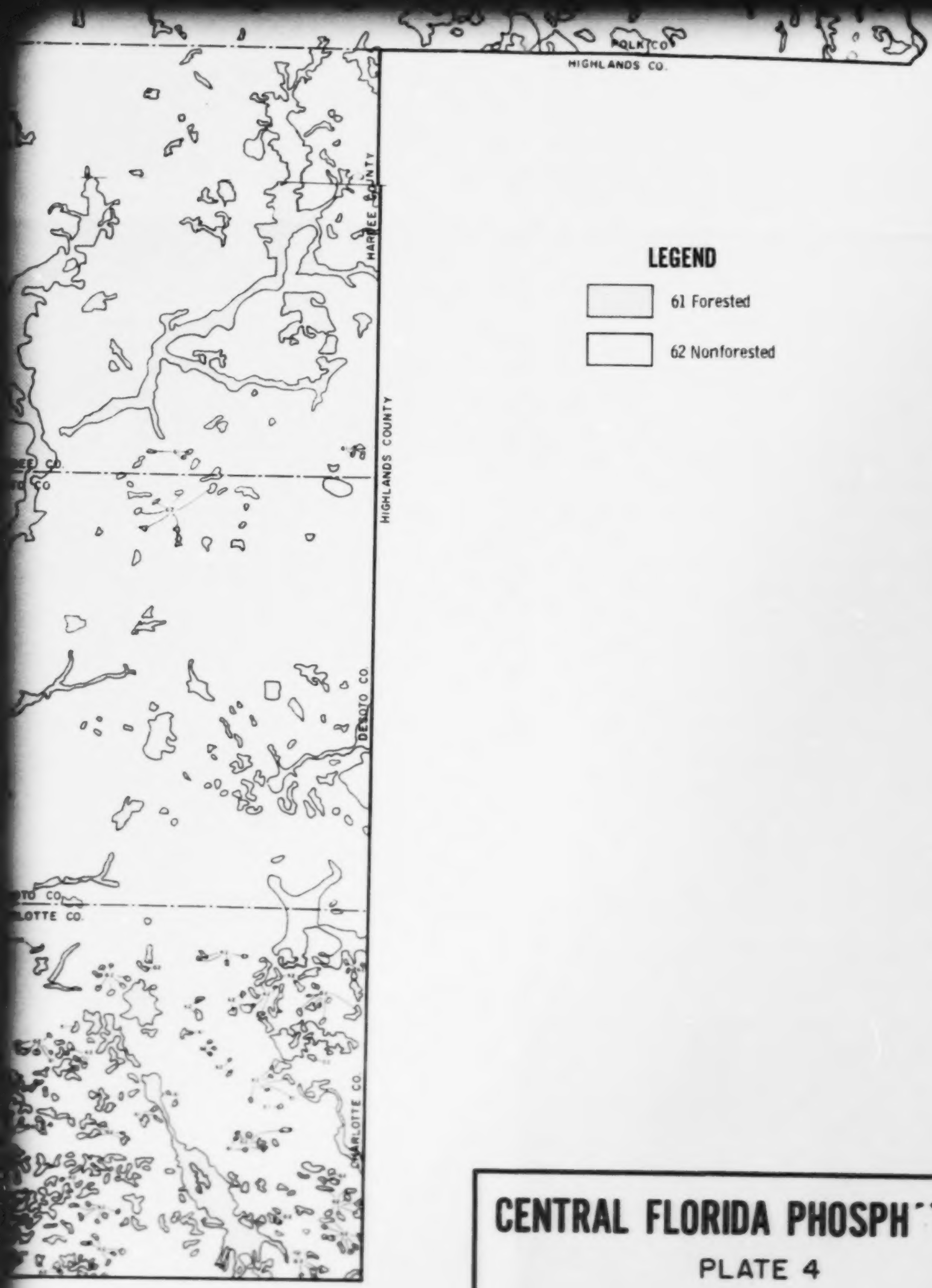
TEXAS IN

EPA Contract No

E


POLK CO.
HIGHLANDS CO.
HARDEE COUNTY
HIGHLANDS COUNTY
EE CO.
O CO
DESOTO CO.
OTO CO.
LOTTE CO.
CHARLOTTE CO.

LEGEND

☐ 61 Forested

☐ 62 Nonforested

CENTRAL FLORIDA PHOSPHATE EIS

PLATE 4

Volume VI

WETLANDS

Prepared by

TEXAS INSTRUMENTS
INCORPORATED

EPA Contract Number 68-01-4196

F

SOIL RATINGS A

A

		Sanitary Facilities				Community Development	
Map Symbol	Name of Association	Septic Tank Absorption Fields	Sewage Lagoons	Sanitary Landfill Trench Type	Shallow Excavations	Dwellings	Light Industry
1	Astatula-Arredondo	Slight	Severe	Severe	Severe	Slight	Slight
2	Arredondo-Ft. Meade-Astatula	Slight	Severe	Severe	Severe	Slight	Slight
3	Tavares-Adamsville	Moderate	Severe	Severe	Severe	Slight	Slight
4	Tavares-Myakka	Moderate	Severe	Severe	Severe	Slight	Slight
5	Pomello-St. Lucie	Severe	Severe	Severe	Severe	Moderate	Moderate
6	Sunniland-Bradenton	Severe	Moderate	Severe	Severe	Severe	Severe
7	Myakka-Pomello-Basinger	Severe	Severe	Severe	Severe	Severe	Severe
8	Myakka-Immokales-Basinger	Severe	Severe	Severe	Severe	Severe	Severe
9	Ona-Myakka	Severe	Severe	Severe	Severe	Severe	Severe
10	Wabasso-Elred-Oldsmar	Severe	Severe	Severe	Severe	Severe	Severe
11	Basinger-Pompano-Swamp	Severe	Severe	Severe	Severe	Severe	Severe
12	Placid-Swamp	Severe	Severe	Severe	Severe	Severe	Severe
13	Brighton-Terra Ceia	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe
14	Freshwater Swamp	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe
15	Saltwater Swamps	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe
16	Mine Pits and Dumps‡	-	-	-	-	-	-
17	Astatula-Tavares-Basinger	Slight	Severe	Severe	Severe	Slight	Slight
18	Pomello-Basinger-St. Lucie	Severe	Severe	Severe	Severe	Moderate	Moderate
19	Myakka-Placid-Swamp	Severe	Severe	Severe	Severe	Severe	Severe
20	Felda-Pompano-Wabasso	Severe	Severe	Severe	Severe	Severe	Severe
21	Paisley-Bushnell	Severe	Slight	Severe	Severe	Severe	Severe
22	Chobee-Delray	Severe	Severe	Severe	Severe	Severe	Severe
23	Brighton-Placid	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe
24	Candler-Tavares	Slight	Severe	Severe	Severe	Slight	Slight
25	Pomello-Myakka-Tavares	Severe	Severe	Severe	Severe	Moderate	Moderate
26	Immokalee-Pomello	Severe	Severe	Severe	Severe	Severe	Severe
27	Wabasso-Felda	Severe	Severe	Severe	Severe	Severe	Severe
28	Pompano-Charlotte-Delray	Severe	Severe	Severe	Severe	Severe	Severe
29	Broward-Bradenton-Manatee	Severe	Severe	Severe	Severe	Moderate	Moderate
30	Wabasso-Bradenton-Myakka	Severe	Severe	Severe	Severe	Severe	Severe
31	Placid-Basinger	Severe	Severe	Severe	Severe	Severe	Severe
32	Delray-Manatee-Pompano	Severe	Severe	Severe	Severe	Severe	Severe

PLATE 5 - Volume VI

OIL RATINGS AND LIMITATIONS AND FEATURES AFFECTING SELECTED USES BY

B

ommunity Development			Water Management		Recreation			Soil Features Aff Water Manageme	
Dwellings	Light Industry	Local Roads and Streets	Embankments Dikes and Levees	Excavated Ponds Aquifer Fed	Camp and Picnic Areas	Play-ground	Paths and Trails	Pond Reservoir Areas	Drainage
Slight	Slight	Slight	Severe	Severe	Severe	Severe	Severe	SE	NN
Slight	Slight	Slight	Severe	Severe	Moderate	Severe	Moderate	SE	NN
Slight	Slight	Slight	Severe	Severe	Moderate	Severe	Moderate	SE	NN
Slight	Slight	Slight	Severe	Severe	Moderate	Severe	Moderate	SE	NN
Moderate	Moderate	Slight	Severe	Moderate	Severe	Severe	Severe	SE	NN
Severe	Severe	Severe	Slight	Moderate	Severe	Severe	Severe	SE	WT
Severe	Severe	Severe	Severe	Moderate	Severe	Severe	Severe	SE	CC,WT
Severe	Severe	Severe	Severe	Moderate	Severe	Severe	Severe	SE	CC,WT
Severe	Severe	Severe	Severe	Moderate	Severe	Severe	Severe	SE	CC,WT
Severe	Severe	Severe	Severe	Moderate	Severe	Severe	Severe	SE	CC,WT
Severe	Severe	Severe	Severe	Slight	Severe	Severe	Severe	SE,SL	CC,WT
Severe	Severe	Severe	Severe	Slight	Severe	Severe	Severe	SE,SL	CC,WT
V.Severe	V.Severe	V.Severe	V.Severe	Slight	V.Severe	V.Severe	V.Severe	SE,SL,EH	WT,EH
V.Severe	V.Severe	V.Severe	NR	Slight	V.Severe	V.Severe	V.Severe	SL	WT,FL
V.Severe	V.Severe	V.Severe	NR	Slight	V.Severe	V.Severe	V.Severe	SL	WT,PO,TF
-	-	-	-	-	-	-	-	-	-
Slight	Slight	Slight	Severe	Severe	Severe	Severe	Severe	SE	NN
Moderate	Moderate	Slight	Severe	Moderate	Severe	Severe	Severe	SE	NN
Severe	Severe	Severe	Severe	Moderate	Severe	Severe	Severe	SE	CC,WT
Severe	Severe	Severe	Severe	Slight	Severe	Severe	Severe	SE	WT
Severe	Severe	Severe	Severe	Slight	Severe	Severe	Severe	FAV	WT,PS
Severe	Severe	Severe	Moderate	Slight	Severe	Severe	Severe	SE	FL,PO,WT
V.Severe	V.Severe	V.Severe	V.Severe	Slight	V.Severe	V.Severe	V.Severe	SE,SL,EH	WT,EH
Slight	Slight	Slight	Severe	Severe	Severe	Severe	Severe	SE	NN
Moderate	Moderate	Slight	Severe	Moderate	Severe	Severe	Severe	SE	NN
Severe	Severe	Severe	Severe	Moderate	Severe	Severe	Severe	SE	CC,WT
Severe	Severe	Severe	Severe	Moderate	Severe	Severe	Severe	SE	CC,WT
Severe	Severe	Severe	Severe	Slight	Severe	Severe	Severe	SE,SL	CC,WT
Moderate	Moderate	Slight	Severe	Severe	Moderate	Moderate	Moderate	SE,DTR	DTR
Severe	Severe	Severe	Severe	Slight	Severe	Severe	Severe	SE	CC,WT
Severe	Severe	Severe	Severe	Slight	Severe	Severe	Severe	SE,SL	CC,WT
ere	Severe	Severe	Severe	Slight	Severe	Severe	Severe	SE,SL	CC,WT

SOIL ASSOCIATIONS*

C

ffecting ment		Suitability as a Source of			Soil Potential for Agriculture**				Suitability as a Habitat for Wildlife		
e	Irrigation	Topsoil	Sand	Roadfill	Capability Unit	Citrus	Truck Crops	Improved Pasture	Openland Wildlife	Woodland Wildlife	Wetland Wildlife
	DTY,PR	Poor	Good	Good	III-IV	High	V.Low	Low	Poor	Poor	V.Poor
	DTY,PR	Poor	Fair	Good	III-IV	High	Moderate	High	Fair	Fair	V.Poor
	DTY,PR	Poor	Good	Good	III	High	Low	Moderate	Fair	Fair	V.Poor
	PR,DTY	Poor	Good	Good	III-IV-VI	High	Low	Moderate	Poor	Poor	V.Poor
	DTY,PR	Poor	Fair	Good	VI-VII	V.Low	V.Low	V.Low	Poor	Poor	V.Poor
	WT	Poor	Poor	Good	III	Moderate	High	High	Fair	Fair	Poor
	WT,PR	Poor	Fair	Good	IV-V-IV	Low	Moderate	High	Fair	Fair	Poor
	WT,PR	Poor	Fair	Good	IV	Low	Moderate	High	Fair	Fair	Poor
	WT,PR	Poor	Fair	Good	III-IV	Low	Moderate	High	Fair	Fair	Poor
	WT	Poor	Poor	Good	III-IV	Moderate	High	High	Fair	Fair	Poor
	WT	Poor	Fair	Good	IV-VII	V.Low	Moderate	Moderate	V.Poor	V.Poor	Good
	WT	Poor	Fair	Good	III-VII	Low	High	High	Fair	Fair	Good
	WT	Poor	Poor	Poor	III	V.Low	High	High	V.Poor	V.Poor	Good
	WT,FL	NR	NR	NR	VII	V.Low	V.Low	V.Low	V.Poor	V.Poor	Good
F	TF,ES,WT	NR	NR	NR	VIII	V.Low	V.Low	V.Low	V.Poor	V.Poor	Good
	-	-	-	-	-	-	-	-	-	-	-
	PR,DTY	Poor	Good	Good	IV-III	High	V.Low	Low	Poor	Poor	V.Poor
	PR,DTY	Poor	Fair	Good	VI-IV-VII	V.Low	V.Low	V.Low	Poor	Poor	V.Poor
	WT,PR	Poor	Fair	Good	IV-III-VII	Low	Moderate	High	Fair	Fair	Poor
	WT	Poor	Fair	Fair	III-IV	Moderate	High	High	Fair	Fair	Fair
	WT,PS	Poor	Poor	Poor	III	Moderate	Moderate	High	Fair	Fair	Good
WT	FL,WT	Fair	Poor	Fair	III	Moderate	Moderate	High	Poor	Poor	Good
	WT	Poor	Poor	Poor	III	V.Low	High	High	V.Poor	V.Poor	Good
	DTY,PR	Poor	Good	Good	IV-III	High	Low	Low	Fair	Fair	V.Poor
	DTY,PR	Poor	Fair	Good	VI-IV-III	V.Low	V.Low	V.Low	Poor	Poor	V.Poor
	WT,PR	Poor	Fair	Good	IV-VI	Low	Moderate	High	Fair	Fair	Poor
	WT	Poor	Poor	Good	III	Moderate	High	High	Fair	Fair	Poor
	WT	Poor	Good	Good	IV-III	V.Low	Moderate	Moderate	Poor	Poor	Fair
	PR	Poor	Fair	Fair	IV-III	Low	High	High	Fair	Poor	Poor
	WT	Poor	Poor	Good	III-IV	Moderate	High	High	Fair	Fair	Poor
	WT	Poor	Fair	Good	III-IV	Low	High	High	Fair	Fair	Good
	WT	Poor	Poor	Good	III-IV	Low	High	High	Fair	Poor	Good
			NR	NR	VII	V.Low	V.Low	V.Low	V.Poor	V.Poor	Good

D

	Soil Potential for Agriculture**				Suitability as a Habitat for Wildlife		
dfill	Capability Unit	Citrus	Truck Crops	Improved Pasture	Openland Wildlife	Woodland Wildlife	Wetland Wildlife
d	III-IV	High	V.Low	Low	Poor	Poor	V.Poor
d	III-IV	High	Moderate	High	Fair	Fair	V.Poor
od	III	High	Low	Moderate	Fair	Fair	V.Poor
d	III-IV-VI	High	Low	Moderate	Poor	Poor	V.Poor
d	VI-VII	V.Low	V.Low	V.Low	Poor	Poor	V.Poor
od	III	Moderate	High	High	Fair	Fair	Poor
od	IV-V-IV	Low	Moderate	High	Fair	Fair	Poor
od	IV	Low	Moderate	High	Fair	Fair	Poor
od	III-IV	Low	Moderate	High	Fair	Fair	Poor
od	III-IV	Moderate	High	High	Fair	Fair	Poor
od	IV-VII	V.Low	Moderate	Moderate	V.Poor	V.Poor	Good
od	III-VII	Low	High	High	Fair	Fair	Good
or	III	V.Low	High	High	V.Poor	V.Poor	Good
	VII	V.Low	V.Low	V.Low	V.Poor	V.Poor	Good
	VIII	V.Low	V.Low	V.Low	V.Poor	V.Poor	Good
-	-	-	-	-	-	-	-
od	IV-III	High	V.Low	Low	Poor	Poor	V.Poor
od	VI-IV-VII	V.Low	V.Low	V.Low	Poor	Poor	V.Poor
od	IV-III-VII	Low	Moderate	High	Fair	Fair	Poor
ir	III-IV	Moderate	High	High	Fair	Fair	Fair
or	III	Moderate	Moderate	High	Fair	Fair	Good
ir	III	Moderate	Moderate	High	Poor	Poor	Good
or	III	V.Low	High	High	V.Poor	V.Poor	Good
od	IV-III	High	Low	Low	Fair	Fair	V.Poor
od	VI-IV-III	V.Low	V.Low	V.Low	Poor	Poor	V.Poor
od	IV-VI	Low	Moderate	High	Fair	Fair	Poor
od	III	Moderate	High	High	Fair	Fair	Poor
od	IV-III	V.Low	Moderate	Moderate	Poor	Poor	Fair
ir	IV-III	Low	High	High	Fair	Poor	Poor
od	III-IV	Moderate	High	High	Fair	Fair	Poor
ood	III-IV	Low	High	High	Fair	Fair	Good
od	III-IV	Low	High	High	Fair	Poor	Good
	III	V.Low	V.Low	V.Low	V.Poor	V.Poor	Good

16	**Mine Pits and Dumps**[†]	-	-	-	-	-	-
17	Astatula-Tavares-Basinger	Slight	Severe	Severe	Severe	Slight	Slight
18	Pomello-Basinger-St. Lucie	Severe	Severe	Severe	Severe	Moderate	Moderate
19	Myakka-Placid-Swamp	Severe	Severe	Severe	Severe	Severe	Severe
20	Felda-Pompano-Wabasso	Severe	Severe	Severe	Severe	Severe	Severe
21	Paisley-Bushnell	Severe	Slight	Severe	Severe	Severe	Severe
22	Chobee-Delray	Severe	Severe	Severe	Severe	Severe	Severe
23	Brighton-Placid	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe
24	Candler-Tavares	Slight	Severe	Severe	Severe	Slight	Slight
25	Pomello-Myakka-Tavares	Severe	Severe	Severe	Severe	Moderate	Moderate
26	Immokalee-Pomello	Severe	Severe	Severe	Severe	Severe	Severe
27	Wabasso-Felda	Severe	Severe	Severe	Severe	Severe	Severe
28	Pompano-Charlotte-Delray	Severe	Severe	Severe	Severe	Severe	Severe
29	Broward-Bradenton-Manatee	Severe	Severe	Severe	Severe	Moderate	Moderate
30	Wabasso-Bradenton-Myakka	Severe	Severe	Severe	Severe	Severe	Severe
31	Placid-Basinger	Severe	Severe	Severe	Severe	Severe	Severe
32	Delray-Manatee-Pompano	Severe	Severe	Severe	Severe	Severe	Severe
33	Freshwater Swamp and Marsh	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe
34	Tidal Marsh and Swamp-Coastal Beach Ridges	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe
35	Pomello-Paola-St. Lucie	Severe	Severe	Severe	Severe	Moderate	Moderate
36	Immokalee-Myakka-Pompano	Severe	Severe	Severe	Severe	Severe	Severe
37	Adamsville-Pompano	Severe	Severe	Severe	Severe	Moderate	Moderate
38	Scranton, var.-Ona-Placid	Severe	Severe	Severe	Severe	Severe	Severe
39	Terra Ceia	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe	V.Severe
40	Pompano, high-Felda	Severe	Severe	Severe	Severe	Moderate	Moderate
41	Pompano, high-Pompano	Severe	Severe	Severe	Severe	Moderate	Moderate
42	Basinger-Placid	Severe	Severe	Severe	Severe	Severe	Severe
43	Bradenton-Wabasso-Felda	Severe	Moderate	Severe	Severe	Severe	Severe
44	Keri-Ft. Drum-Hallandale	Severe	Severe	Severe	Severe	Moderate	Moderate
45	Felda-Manatee	Severe	Severe	Severe	Severe	Severe	Severe

*The overall rating for the association is based on the rating for the dominant soil (soil that make
or soils if more than one soil has the same rating.

**High-level management is assumed, which includes water management

[†] Areas not rated since they consist of highly variable material. Site investigation necessary.

Abbreviations

CC - Cutbanks cave
DTR- Depth to rock
DTY- Droughty
EH - Excess humus
ES - Excess salt

FAV - Soil characteristics favorable
FL - Floods
NN - Not needed
PO - Poor outlets
PR - Percolates rapidly

PS - Percolates slowly
SE - Seepage
SL - Slope
TF - Tidal flooding
WT - Wet

E

	Slight	Slight	Severe	Severe	Severe	Severe	Severe	SE	NN	PR,D
e	Moderate	Slight	Severe	Moderate	Severe	Severe	Severe	SE	NN	PR,DT
	Severe	Severe	Severe	Moderate	Severe	Severe	Severe	SE	CC,WT	WT,PR
	Severe	Severe	Severe	Slight	Severe	Severe	Severe	SE	WT	WT
	Severe	Severe	Severe	Slight	Severe	Severe	Severe	FAV	WT,PS	WT,PS
	Severe	Severe	Moderate	Slight	Severe	Severe	Severe	SE	FL,PO,WT	FL,WT
re	V.Severe	V.Severe	V.Severe	Slight	V.Severe	V.Severe	V.Severe	SE,SL,EH	WT,EH	WT
	Slight	Slight	Severe	Severe	Severe	Severe	Severe	SE	NN	DTY,P
te	Moderate	Slight	Severe	Moderate	Severe	Severe	Severe	SE	NN	DTY,P
	Severe	Severe	Severe	Moderate	Severe	Severe	Severe	SE	CC,WT	WT,PR
	Severe	Severe	Severe	Moderate	Severe	Severe	Severe	SE	CC,WT	WT
	Severe	Severe	Severe	Slight	Severe	Severe	Severe	SE,SL	CC,WT	WT
te	Moderate	Slight	Severe	Severe	Moderate	Moderate	Moderate	SE,DTR	DTR	PR
	Severe	Severe	Severe	Slight	Severe	Severe	Severe	SE	CC,WT	WT
	Severe	Severe	Severe	Slight	Severe	Severe	Severe	SE,SL	CC,WT	WT
	Severe	Severe	Severe	Slight	Severe	Severe	Severe	SE,SL	CC,WT	WT
re	V.Severe	V.Severe	NR	Slight	V.Severe	V.Severe	V.Severe	SL	WT,FL	WT,FL
re	V.Severe	V.Severe	NR	Slight	V.Severe	V.Severe	V.Severe	SL	PO,TF,WT	TF,ES,
te	Moderate	Slight	Severe	Moderate	Severe	Severe	Severe	SE	NN	DRY,P
	Severe	Severe	Severe	Moderate	Severe	Severe	Severe	SE	CC,WT	WT,PR
te	Moderate	Moderate	Severe	Moderate	Moderate	Severe	Severe	SE	CC,WT	WT,PR
	Severe	Severe	Severe	Moderate	Severe	Severe	Severe	PR	WT,CC	PR,WT
re	V.Severe	V.Severe	V.Severe	Slight	V.Severe	V.Severe	V.Severe	SE,SL,EH	WT,EH	WT
te	Moderate	Moderate	Severe	Moderate	Moderate	Severe	Severe	SE	CC,WT	WT,PR
te	Moderate	Moderate	Severe	Moderate	Moderate	Severe	Severe	SE	CC,WT	WT,PR
	Severe	Severe	Severe	Slight	Severe	Severe	Severe	SE,SL	CC,WT	WT
	Severe	Severe	Slight	Moderate	Severe	Severe	Severe	SE	WT	WT
te	Moderate	Moderate	Severe	Moderate	Moderate	Moderate	Moderate	SE	WT	PR
	Severe	Severe	Severe	Slight	Severe	Severe	Severe	SE	WT	WT

oil that makes up the greatest percentage of the association)

cessary.

F

	NN	PR,DTY	Poor	Fair	Good	VI-IV-VII	V.Low	V.Low	V.Low	Poor	Po
	CC,WT	WT,PR	Poor	Fair	Good	IV-III-VII	Low	Moderate	High	Fair	Fa
	WT	WT	Poor	Fair	Fair	III-IV	Moderate	High	High	Fair	Fa
	WT,PS	WT,PS	Poor	Poor	Poor	III	Moderate	Moderate	High	Fair	Fa
	FL,PO,WT	FL,WT	Fair	Poor	Fair	III	Moderate	Moderate	High	Poor	Po
L,EH	WT,EH	WT	Poor	Poor	Poor	III	V.Low	High	High	V.Poor	V.P
	NN	DTY,PR	Poor	Good	Good	IV-III	High	Low	Low	Fair	Fa
	NN	DTY,PR	Poor	Fair	Good	VI-IV-III	V.Low	V.Low	V.Low	Poor	Po
	CC,WT	WT,PR	Poor	Fair	Good	IV-VI	Low	Moderate	High	Fair	Fa
	CC,WT	WT	Poor	Poor	Good	III	Moderate	High	High	Fair	Fa
L	CC,WT	WT	Poor	Good	Good	IV-III	V.Low	Moderate	Moderate	Poor	Po
TR	DTR	PR	Poor	Fair	Fair	IV-III	Low	High	High	Fair	Po
	CC,WT	WT	Poor	Poor	Good	III-IV	Moderate	High	High	Fair	Fa
L	CC,WT	WT	Poor	Fair	Good	III-IV	Low	High	High	Fair	Fa
L	CC,WT	WT	Poor	Poor	Good	III-IV	Low	High	High	Fair	Po
	WT,FL	WT,FL	NR	NR	NR	VII	V.Low	V.Low	V.Low	V.Poor	V.
	PO,TF,WT	TF,ES,WT	NR	NR	NR	VIII	V.Low	V.Low	V.Low	V.Poor	V.
	NN	DRY,PR	Poor	Fair	Good	VI-VII	V.Low	V.Low	V.Low	Poor	Po
	CC,WT	WT,PR	Poor	Fair	Good	IV	Low	Moderate	High	Fair	Fa
	CC,WT	WT,PR	Poor	Fair	Good	III-IV	Moderate	High	High	Poor	Fa
	WT,CC	PR,WT	Fair	Fair	Good	III	Moderate	High	High	Poor	Go
SL,EH	WT,EH	WT	Poor	Poor	Poor	III	V.Low	High	High	Poor	Po
	CC,WT	WT,PR	Poor	Fair	Good	IV-III	Moderate	High	High	Poor	Fa
	CC,WT	WT,PR	Poor	Fair	Good	IV	Moderate	High	High	Poor	Fa
L	CC,WT	WT	Poor	Fair	Good	IV-III	V.Low	Moderate	Moderate	V.Poor	V.
	WT	WT	Poor	Poor	Good	III	Moderate	High	High	Fair	Fa
	WT	PR	Poor	Poor	Good	IV	Low	High	High	Fair	Po
	WT	WT	Poor	Fair	Fair	III	Moderate	High	High	Fair	Fa

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NR	NR	NR	VIII	V.Low	V.Low	V.Low	[illegible]	[illegible]	[illegible]
-	-	-	-	-	-	-	-	-	-
Poor	Good	Good	IV-III	High	V.Low	Low	Poor	Poor	V.Poor
Poor	Fair	Good	VI-IV-VII	V.Low	V.Low	V.Low	Poor	Poor	V.Poor
Poor	Fair	Good	IV-III-VII	Low	Moderate	High	Fair	Fair	Poor
Poor	Fair	Fair	III-IV	Moderate	High	High	Fair	Fair	Fair
Poor	Poor	Poor	III	Moderate	Moderate	High	Fair	Fair	Good
Fair	Poor	Fair	III	Moderate	Moderate	High	Poor	Poor	Good
Poor	Poor	Poor	III	V.Low	High	High	V.Poor	V.Poor	Good
Poor	Good	Good	IV-III	High	Low	Low	Fair	Fair	V.Poor
Poor	Fair	Good	VI-IV-III	V.Low	V.Low	V.Low	Poor	Poor	V.Poor
Poor	Fair	Good	IV-VI	Low	Moderate	High	Fair	Fair	Poor
Poor	Poor	Good	III	Moderate	High	High	Fair	Fair	Poor
Poor	Good	Good	IV-III	V.Low	Moderate	Moderate	Poor	Poor	Fair
Poor	Fair	Fair	IV-III	Low	High	High	Fair	Poor	Poor
Poor	Poor	Good	III-IV	Moderate	High	High	Fair	Fair	Poor
Poor	Fair	Good	III-IV	Low	High	High	Fair	Fair	Good
Poor	Poor	Good	III-IV	Low	High	High	Fair	Poor	Good
NR	NR	NR	VII	V.Low	V.Low	V.Low	V.Poor	V.Poor	Good
NR	NR	NR	VIII	V.Low	V.Low	V.Low	V.Poor	V.Poor	Good
Poor	Fair	Good	VI-VII	V.Low	V.Low	V.Low	Poor	Poor	V.Poor
Poor	Fair	Good	IV	Low	Moderate	High	Fair	Fair	Poor
Poor	Fair	Good	III-IV	Moderate	High	High	Poor	Fair	Poor
Fair	Fair	Good	III	Moderate	High	High	Poor	Good	V.Poor
Poor	Poor	Poor	III	V.Low	High	High	Poor	Poor	Good
Poor	Fair	Good	IV-III	Moderate	High	High	Poor	Fair	Poor
Poor	Fair	Good	IV	Moderate	High	High	Poor	Fair	Poor
Poor	Fair	Good	IV-III	V.Low	Moderate	Moderate	V.Poor	V.Poor	Good
Poor	Poor	Good	III	Moderate	High	High	Fair	Fair	Poor
Poor	Poor	Good	IV	Low	High	High	Fair	Poor	Poor
Poor	Fair	Fair	III	Moderate	High	High	Fair	Fair	Fair

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